Run the Engine

an I-DEAS Exercise in
Mechanism Simulation

by

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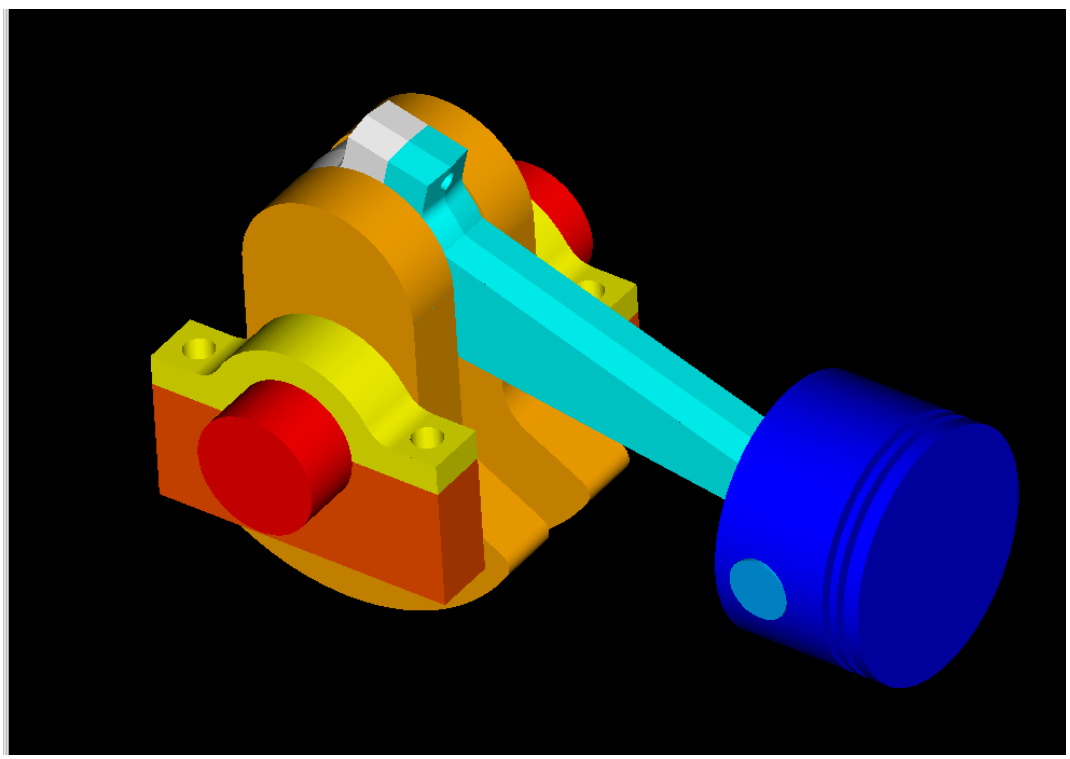


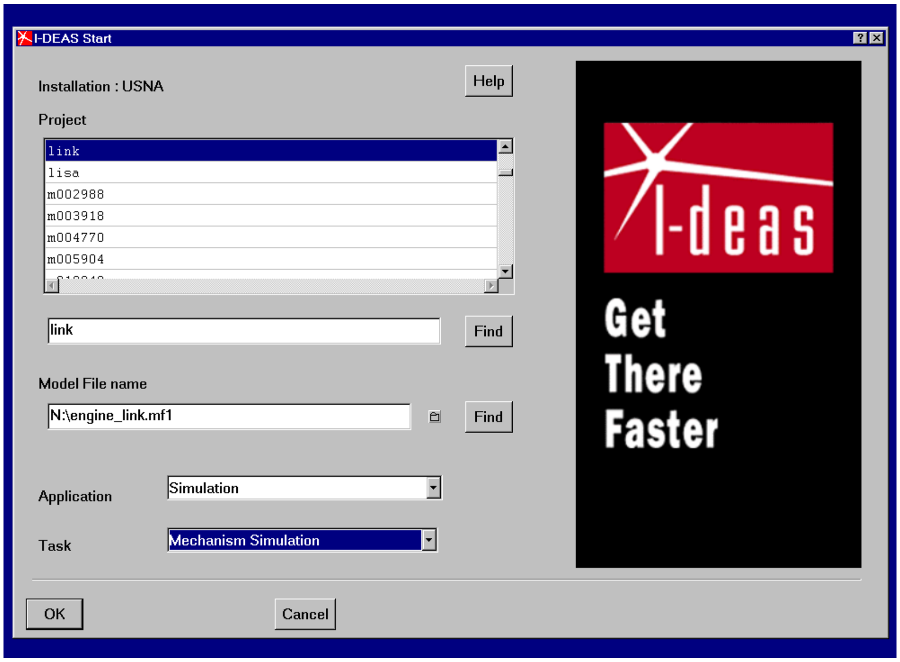
Run the Engine

In this exercise you will perform a kinematic analysis of the engine. Here are some tips to remember when going through the exercise:

- Pay attention to the I-DEAS List and Prompt regions at the bottom of the large display window. The prompt region asks you for feedback or to select entities, the List region provides information.
- You can elect the default response from the prompt region by clicking the center mouse button. The button assignments are:
  - Left button - pick or select (LMB)
  - Middle button - Done or OK or accept default (MMB)
  - Right button - display list of options for current command (RMB)
- Save your work after the completion of every successful step. If you make a mistake on the next operation, you can recover to the model state from the last *Save* by typing *Ctrl-z*. There is no general Undo feature in I-DEAS!
- Use the Dynamic Viewing buttons (F1-Pan, F2-Zoom, and F3-3D Rotate) to adjust the display while you are in the middle of a command to help you select the entity you want. Hold the appropriate button down and drag the mouse in the display region.
- In this tutorial, messages that appear in the prompt region are shown in highlight.

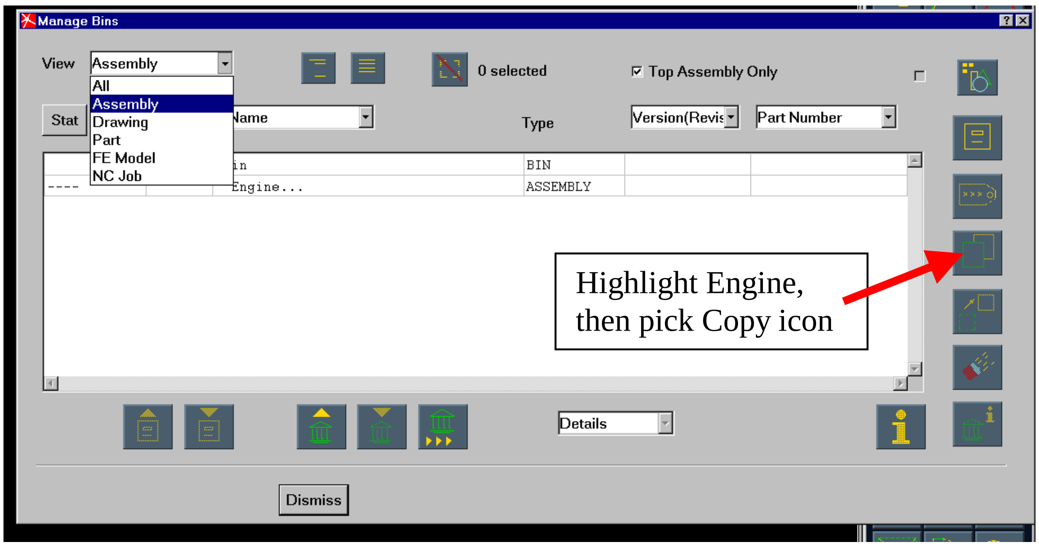
1. Open your model file in the Simulation applications and the Mechanism Simulation task. Just switch to this task if your model file is already open.

There are many steps to this tutorial. *Save your work often!*



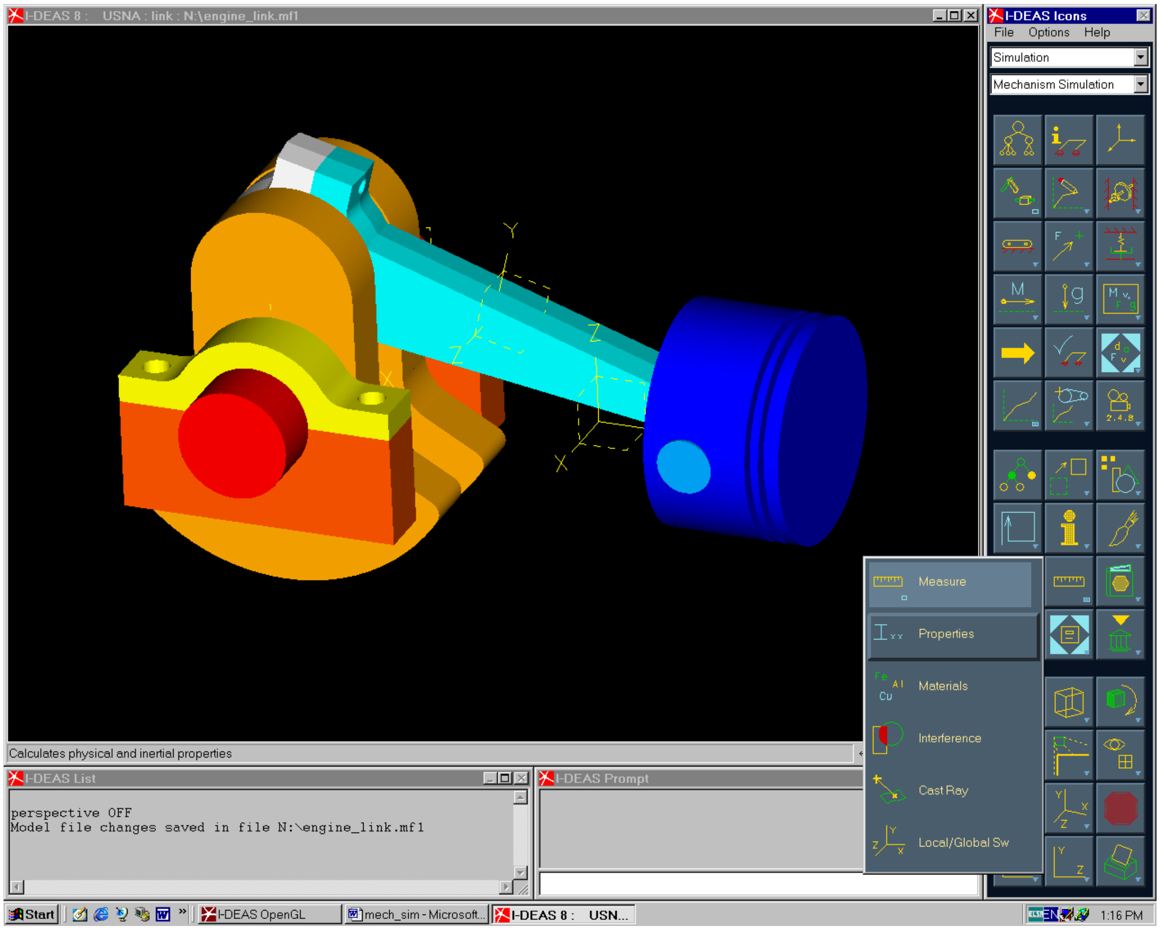
2. Pick the **Manage Bins…** icon, pull down *Assembly* from the View list.

Select *Engine*, then pick the **Copy** icon. Call the copy *Engine Mechanism* and **Get** from the Bin onto the workbench. This way you have a good assembly to work from if you make a mistake.

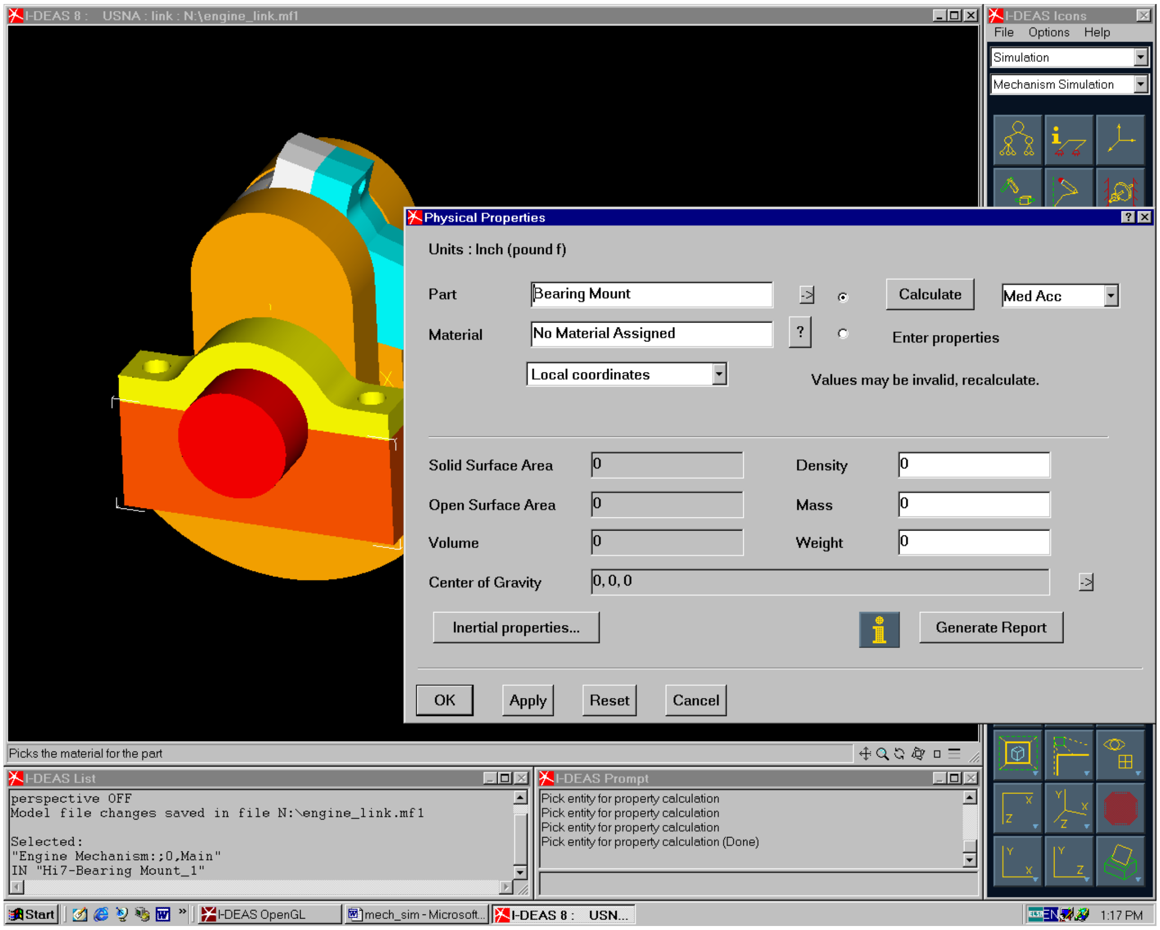


Save your file.

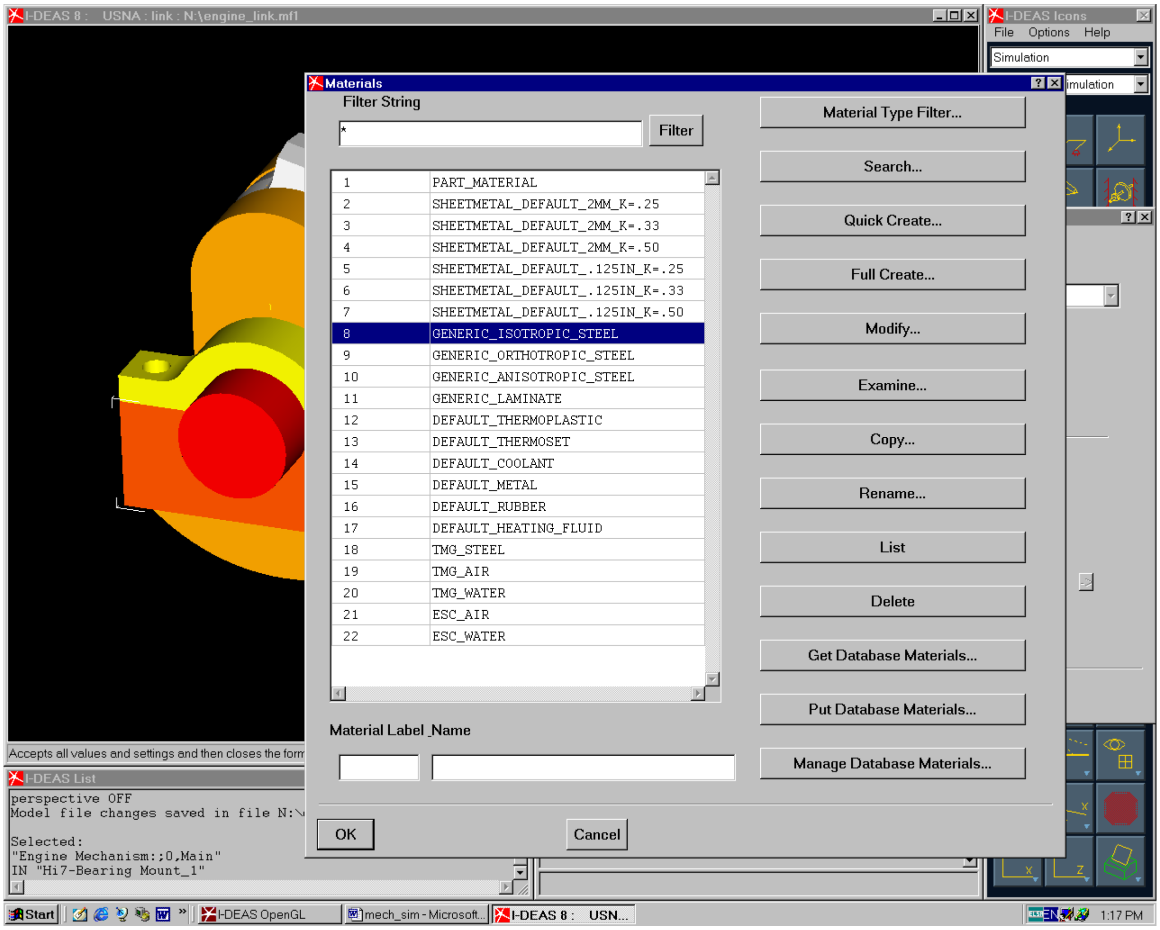
3. Then next step is to assign a material to each part of the assembly. This is necessary so that the software can compute the mass of the various components. Pick the **Properties** icon.



4. You will be prompted to pick an entity. Pick the *Bearing Mount* and the form shown below will display. Notice that no material is assigned to the part. Click on the **?** icon following the Material box.



5. A list of standard materials will display. Pick *GENERIC_ISOTROPIC_STEEL*, then pick **OK.**



Repeat this process to assign the steel material properties to the Bearing Cap, the Piston Pin and the Crankshaft.

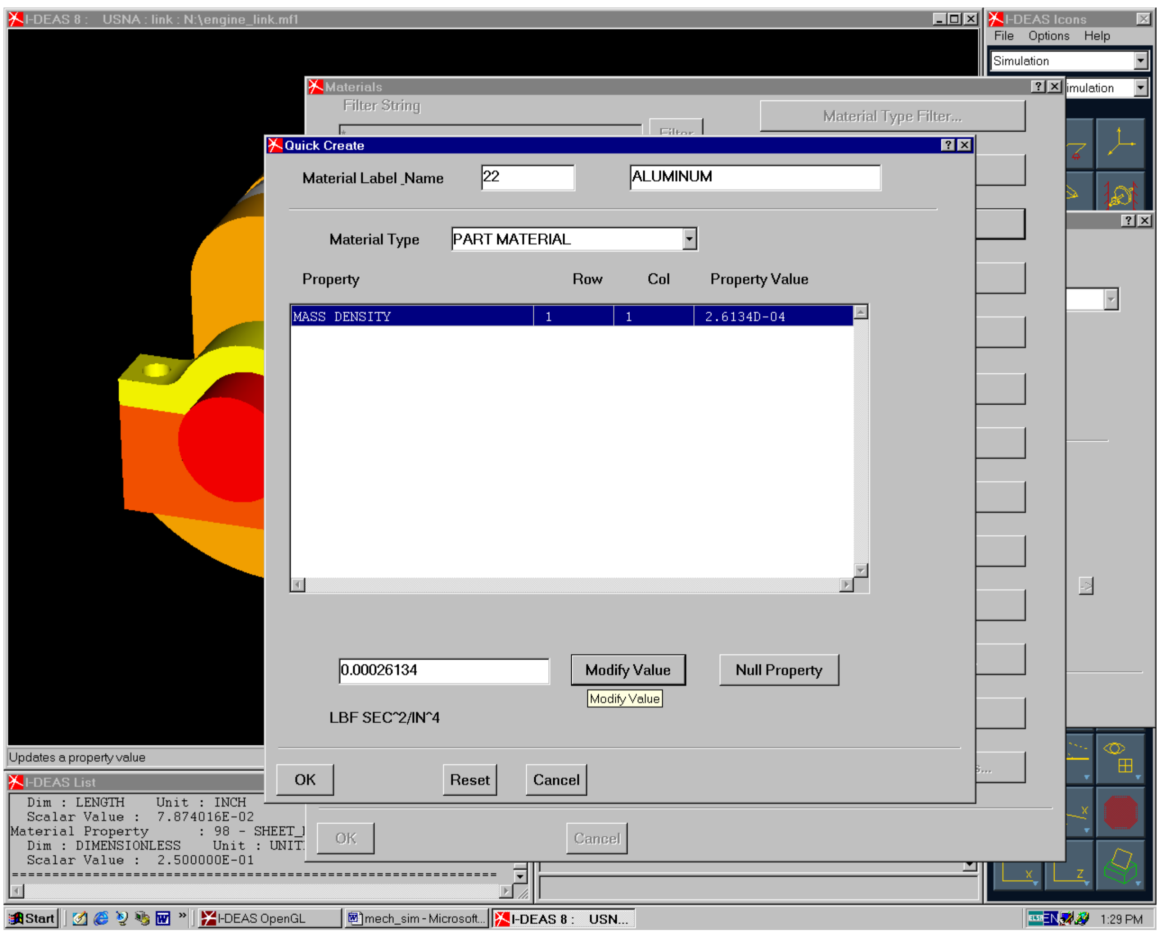
Save your model file.

6. We would like to assign the piston and the connecting rod properties for Aluminum, but that choice is not on the list so we must create this material using **Quick Create** or get additional materials from one of the material databases. Pick the **Quick Create** button.

Change the *Material Name* to Aluminum.

Pick the *Mass Density* property and type 0.00026134 into the box at the bottom of the form, then pick **Modify Value** button.

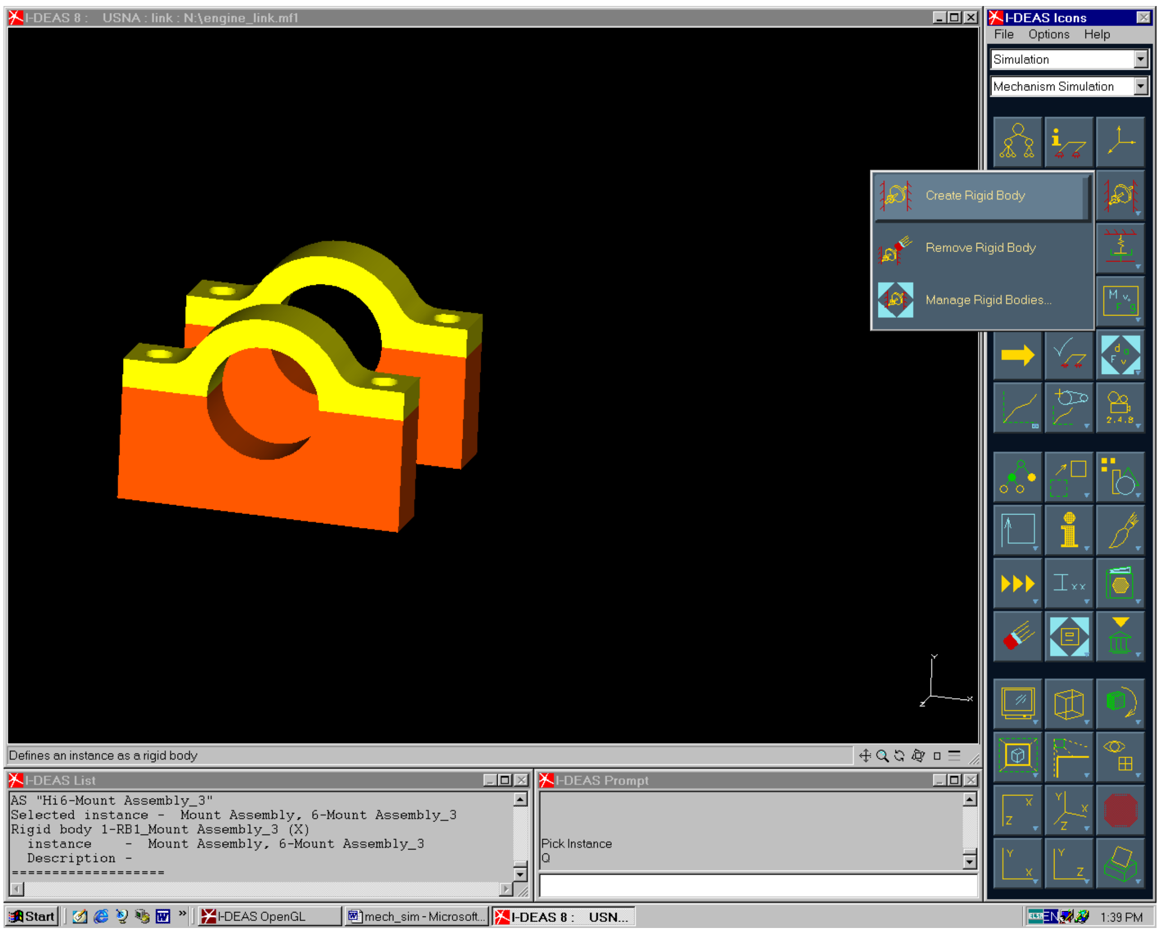
Now you can pick Aluminum as the material to assign to the *Connecting Rod*, the *Rod End* and the *Piston*.



Save your file.

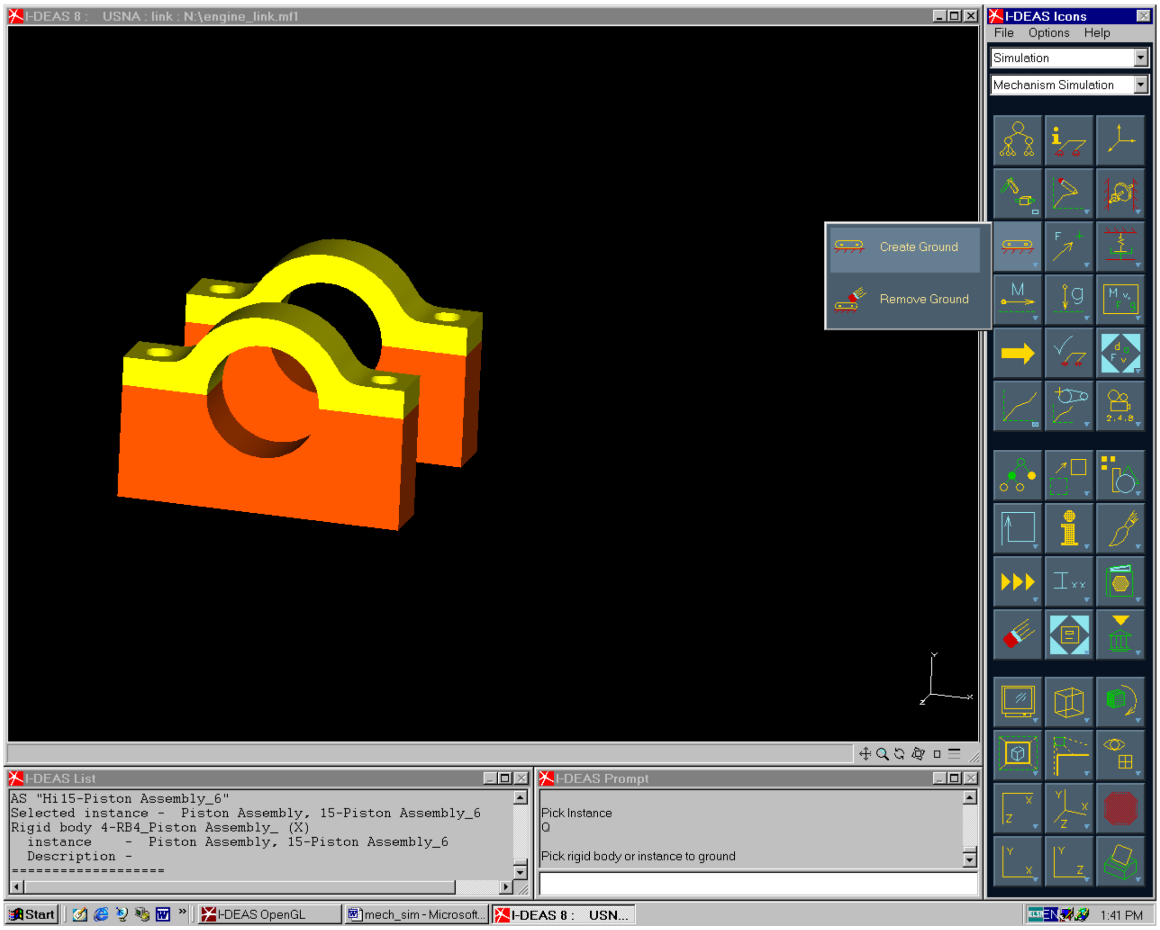
7. The next step in the process is to define the rigid bodies that make up our mechanism. The piston engine is a crank-slider type of four-bar mechanism so we must group all of our parts into four appropriate rigid bodies and add the necessary joints and grounds.

Pick the **Create Rigid Body** icon, **RMB… Hierarchy**, and pick one of the Mount Assembly entities, then **OK**. Repeat for other Mount Assembly, Connecting Rod Assembly and Piston Assembly



Save your file.

8. Both of the Mount Assemblies are the ground instances for our mechanism, so we need to identify them as such. Pick the **Create Ground** icon, **RMB**, **Hierarchy…**, and pick one of the Mount Assembly instances, then **OK**, repeat for other Mount Assembly.



Save your file.

9. **Suppress** all but the two Mount Assemblies and the Crankshaft.

In the following pages, text that appears in the I-DEAS Prompt region is displayed in highlight.

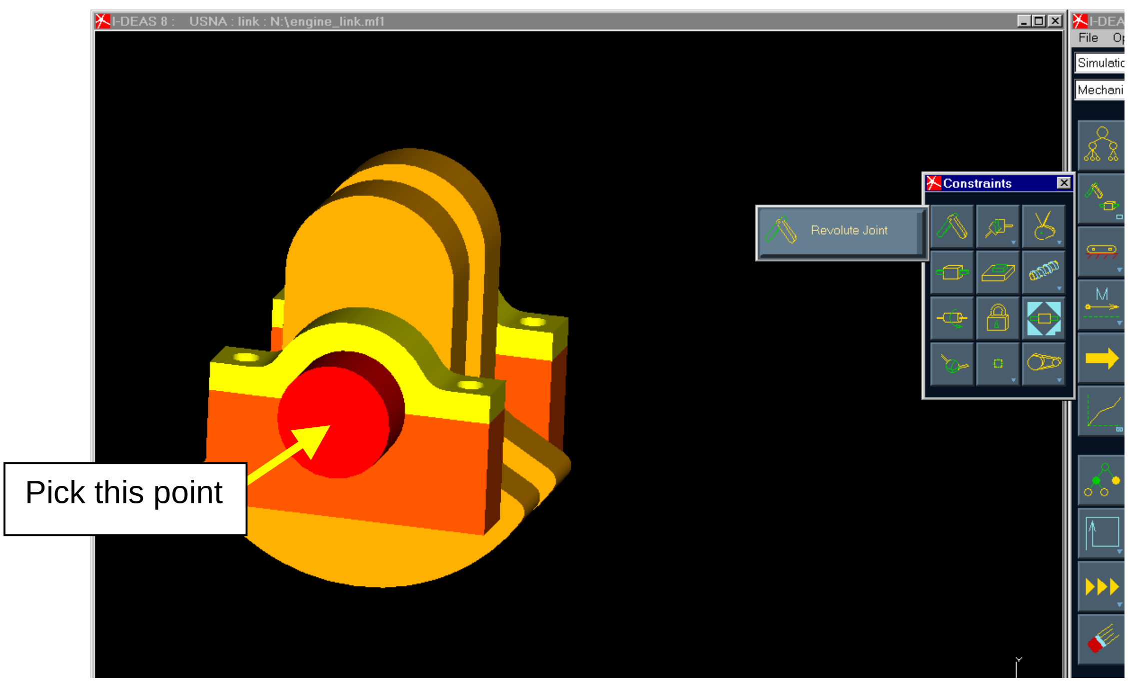
Pick the **Create Joints** icon. Pick **Revolute Joint** from the icon panel.
Pick joint origin on the first rigid body - **RMB**, **Between**.

Pick first point -

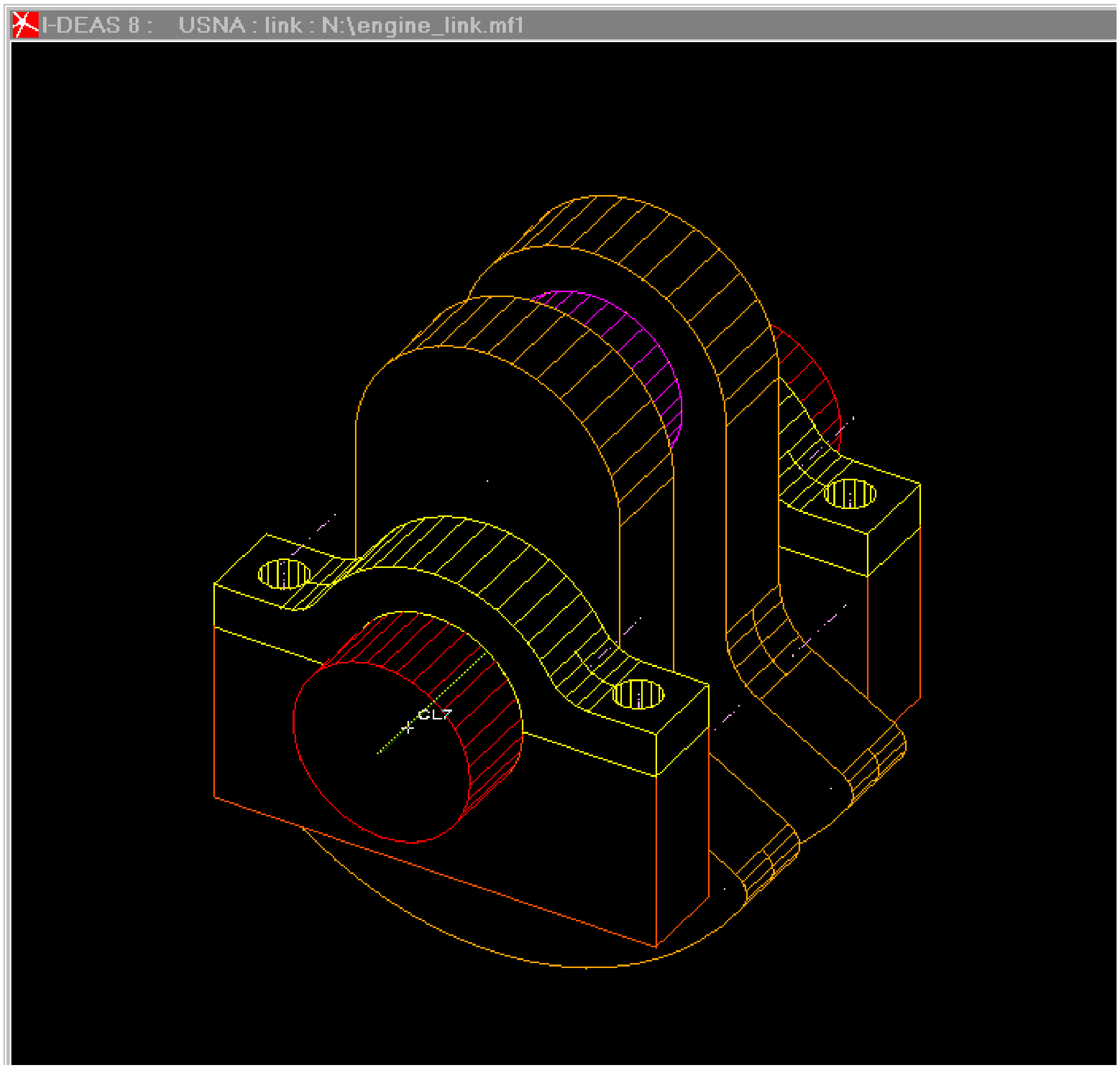
Pick the centerpoint from near end of crank journal and then centerpoint from far end of crank journal as second point. (Use F3 to reorient the model to pick the other centerpoint).

Enter percent between (50.0) - Hit Enter to accept default.

Pick point on second rigid body - select any point on the Mount Assembly

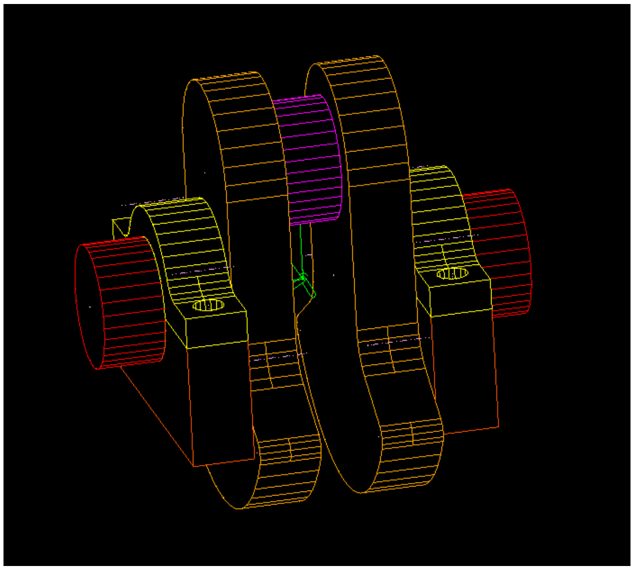


Pick vector defining axis of rotation - pick centerline of crank journal.



Is direction OK? - Pick **Yes** if you like direction of arrow, **No** if you want the other direction of rotation to be positive (right-hand rule).

Switch to **Line Display Mode** and you should see a marker for the revolute joint located midway along the crank journal axis.



Save your file.

Why did we put the joint in the middle of the crankshaft?

Because we are defining a 2-D planar mechanism and we don't want to develop out-of-plane reactions on the joints. If we had placed a revolute joint at each Mount Assembly, the software would identify one as being redundant and ignore it in subsequent analyses.

10. Pick the **Hierarchy** icon and suppress the two *Mount Assembly* instances. Unsuppress *Connecting Rod Assembly*.

Next, add a revolute joint between Crankshaft and the Connecting Rod. The procedure is similar to that followed for the previous joint. Pick the **Revolute Joint** icon.

Pick joint origin on the first rigid body - **RMB**, **Between**.

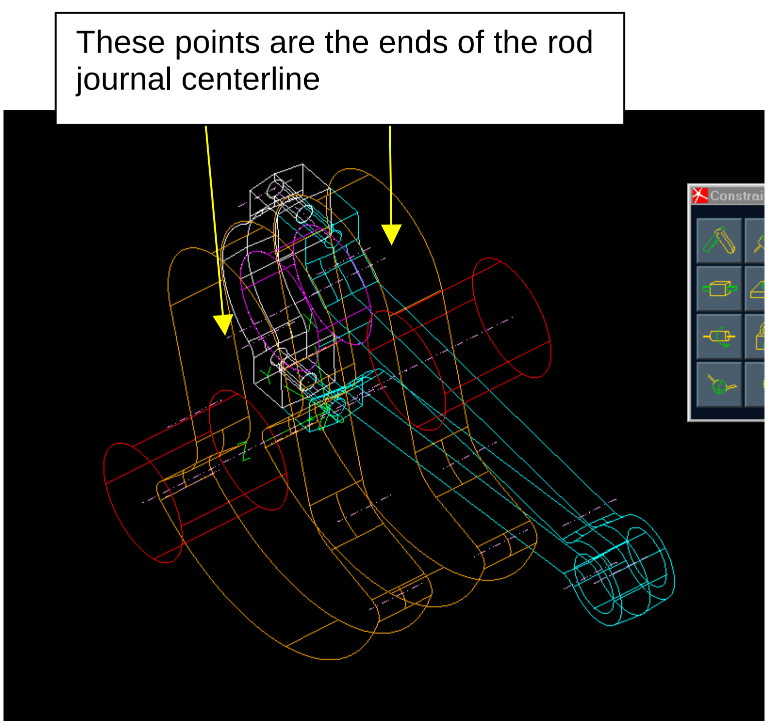
Pick first point -
Pick one end point of rod journal centerline from the crankshaft. Pick the other end of the centerline as the second point.

Enter percent between (50.0)

Hit Enter to accept default.

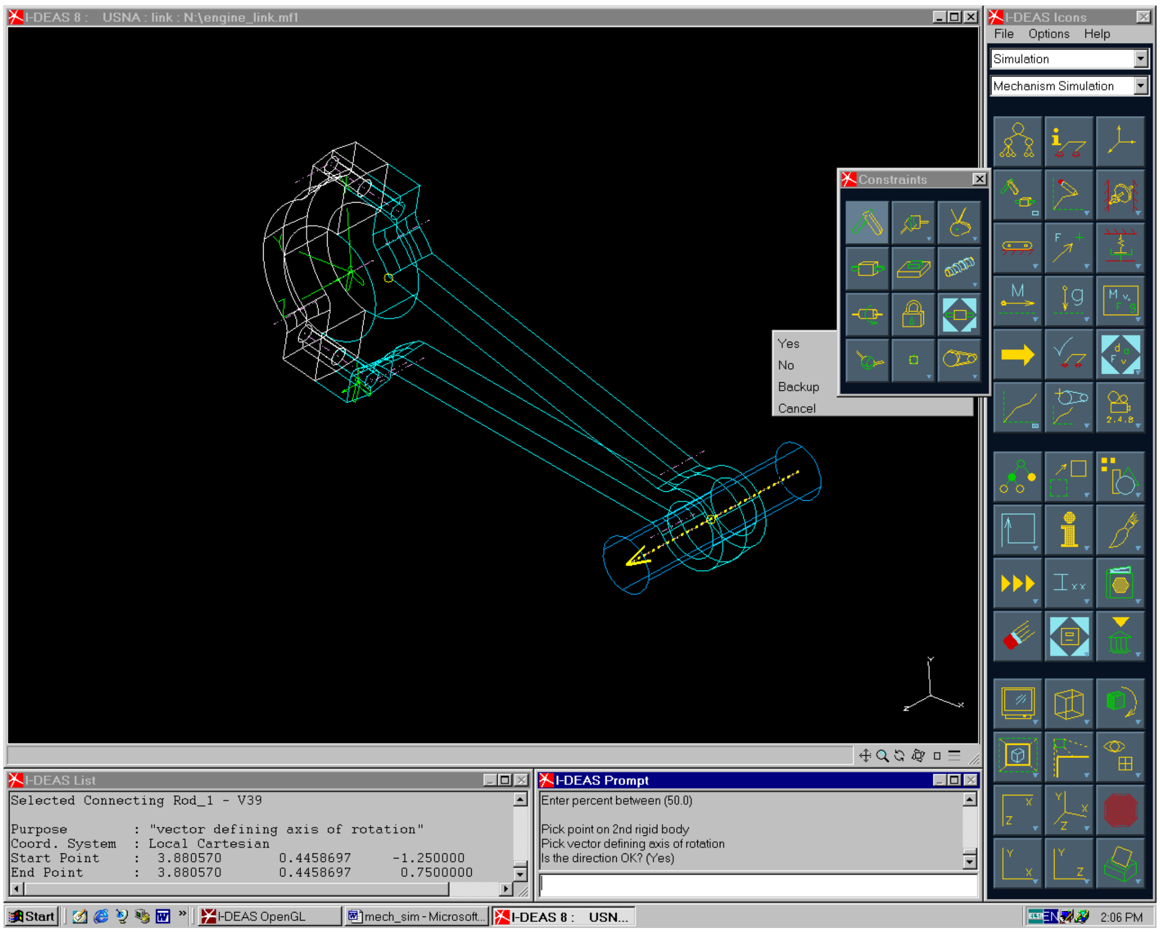
Pick point on second rigid body - pick any point on the Connecting Rod as second entity.

Pick the rod journal centerline as the axis of rotation, and make sure vector is in same direction as for first joint.



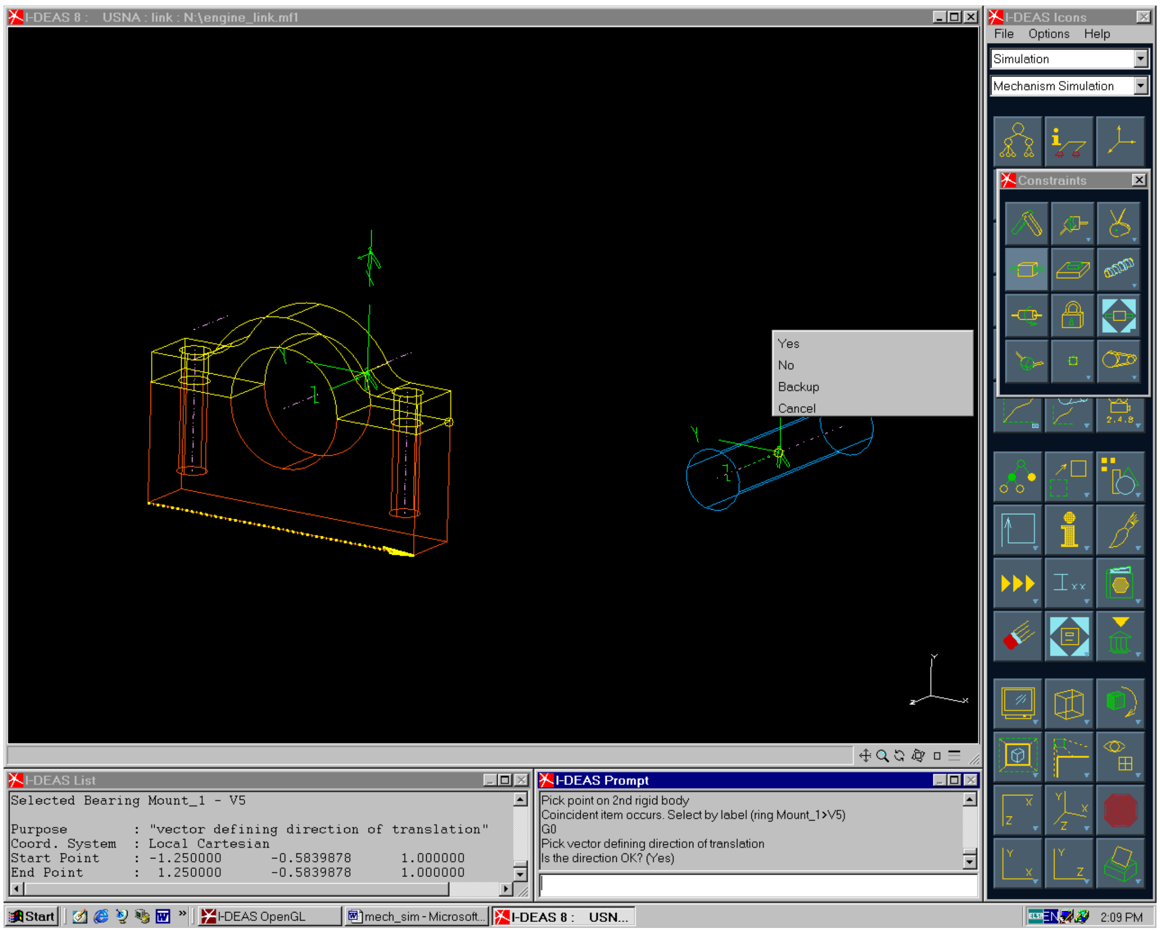
11. Pick the Hierarchy icon and **Suppress** the *Crankshaft*. **Unsuppress** the *Piston Pin*

Add a revolute joint between the *Connecting Rod* and the *Piston Pin*. Pick the joint origin 50% between the ends of the *Piston Pin*. The axis of rotation should be in the same direction as the other two revolute joints.



12. Pick the **Hierarchy** icon, **Suppress** the *Connecting Rod Assembly*. **Unsuppress** the near *Mount Assembly*.

Add a **Translational Joint** between the *Piston Pin* and the *Mount Assembly*. Locate the joint 50% between ends of piston pin. Pick the *Mount Assembly* as second rigid body, and pick the long edge at bottom of the *Mount* as the vector defining the axis of translation.



Pick the **Hierarchy** icon and **Unsuppress** all instances.

Save your file.

13. Pick Mechanism Check icon,

The I-DEAS List region should display something like this:

```
"Engine Mechanism:;0,Main"
AS "Hi1-Engine_0"
2  REVOLUTE2          (REVOLUTE)
   Joint Variable ( 0.0) deg
3  REVOLUTE3          (REVOLUTE)
   Joint Variable ( 0.0) deg
4  REVOLUTE4          (REVOLUTE)
   Joint Variable ( 0.0) deg
5  TRANSLATIONAL5     (TRANSLATIONAL)
   Joint Variable ( 0.0) in
All joints are valid.
  GROUNDS
==========================
 1-RB1_MOUNT ASSEMBLY_3
 2-RB2_MOUNT ASSEMBLY_3
2 grounds
The mechanism has 1 degree(s) of freedom.
The mechanism has 3 redundant constraint(s).
The following redundant joint constraints will be removed:
 - REVOLUTE3, Rotation about Y
 - REVOLUTE3, Rotation about X
 - REVOLUTE4, Rotation about X
```

This shows that there are four joints and that the mechanism has 1 degree of freedom, which is what we expect for a four-bar mechanism.

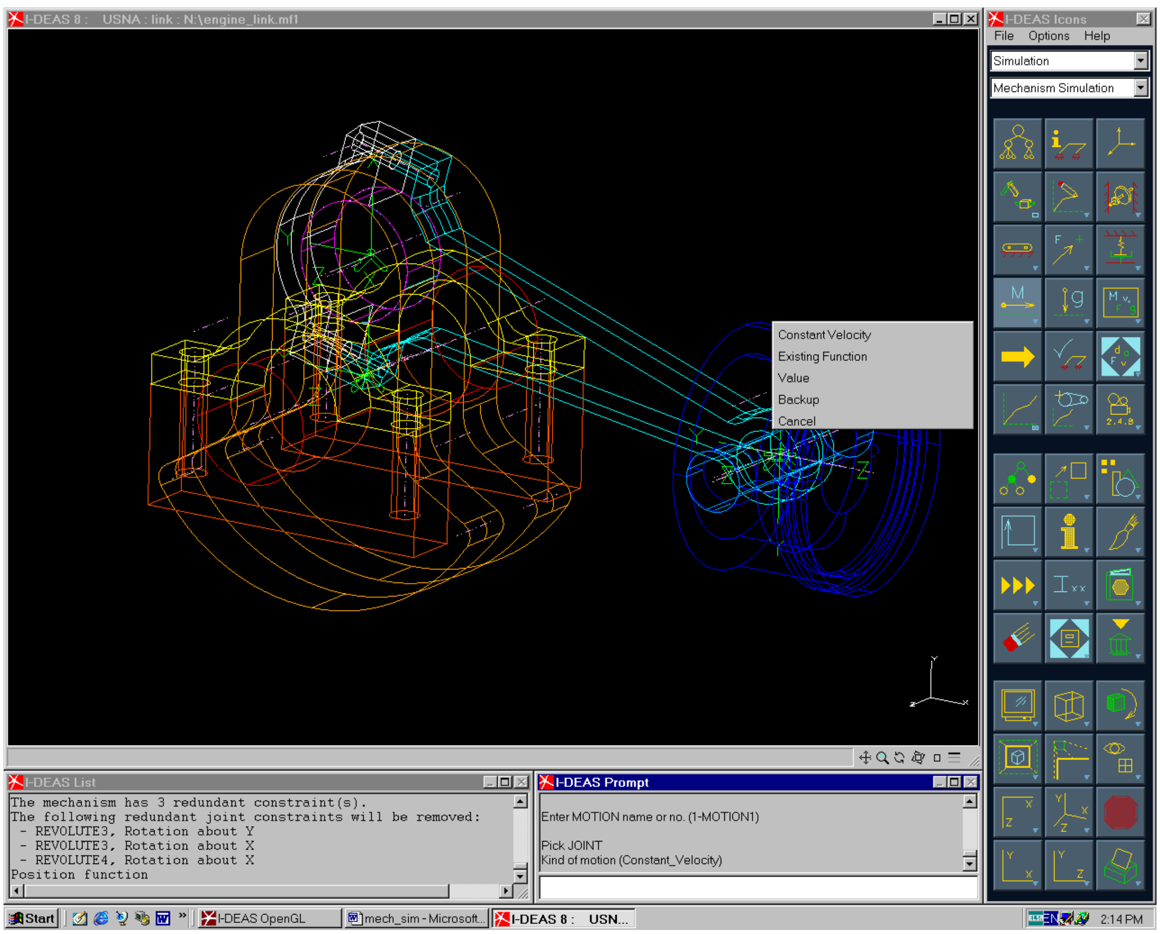
14. The next step is to define the input function to drive the mechanism. Pick the **Create Motion** icon.

Enter Motion name - accept the default.

Pick joint – pick the joint between the Mount Assembly and the Crankshaft journal (the first one we created),

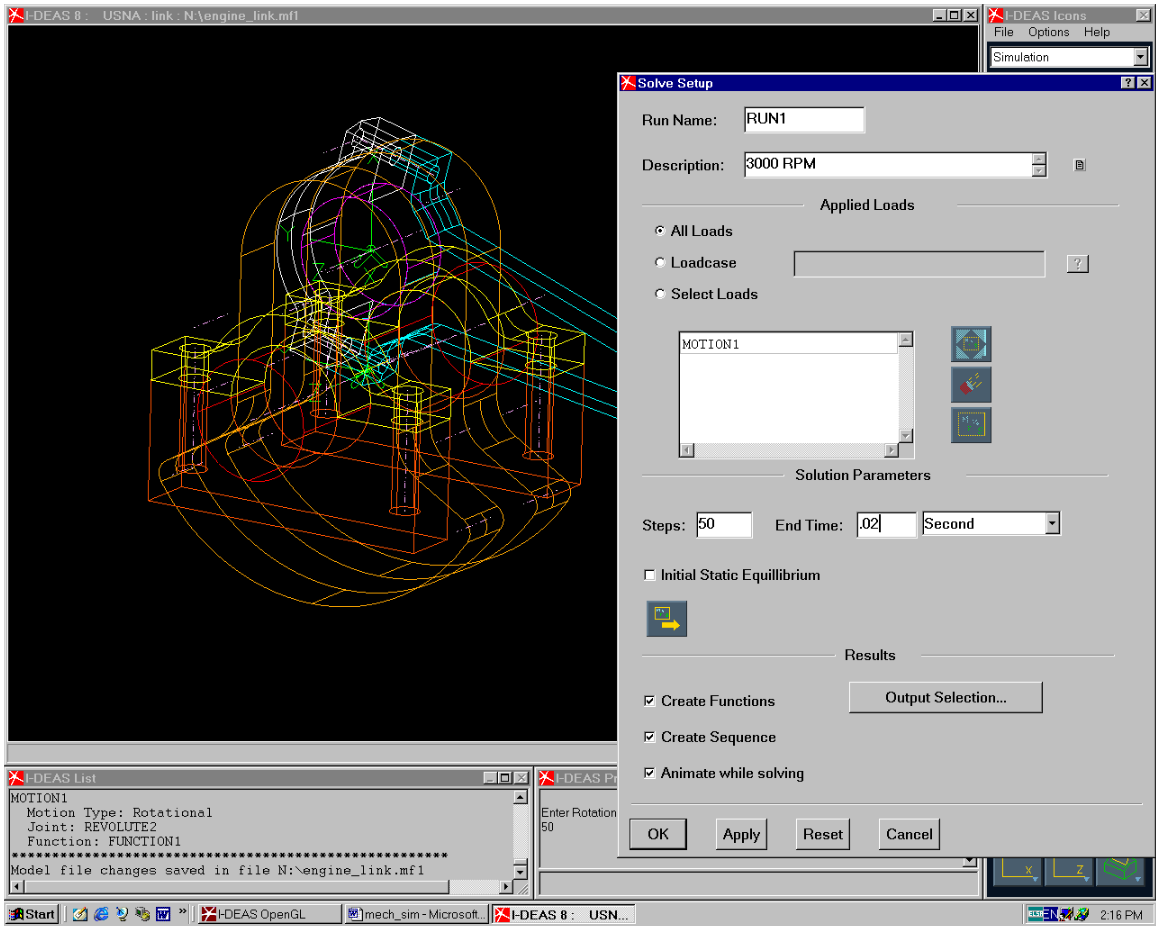
Kind of Motion, accept default of Constant Velocity

Rotational Velocity - type in 50 and Enter (This is 50 rev/s or 3000 RPM)



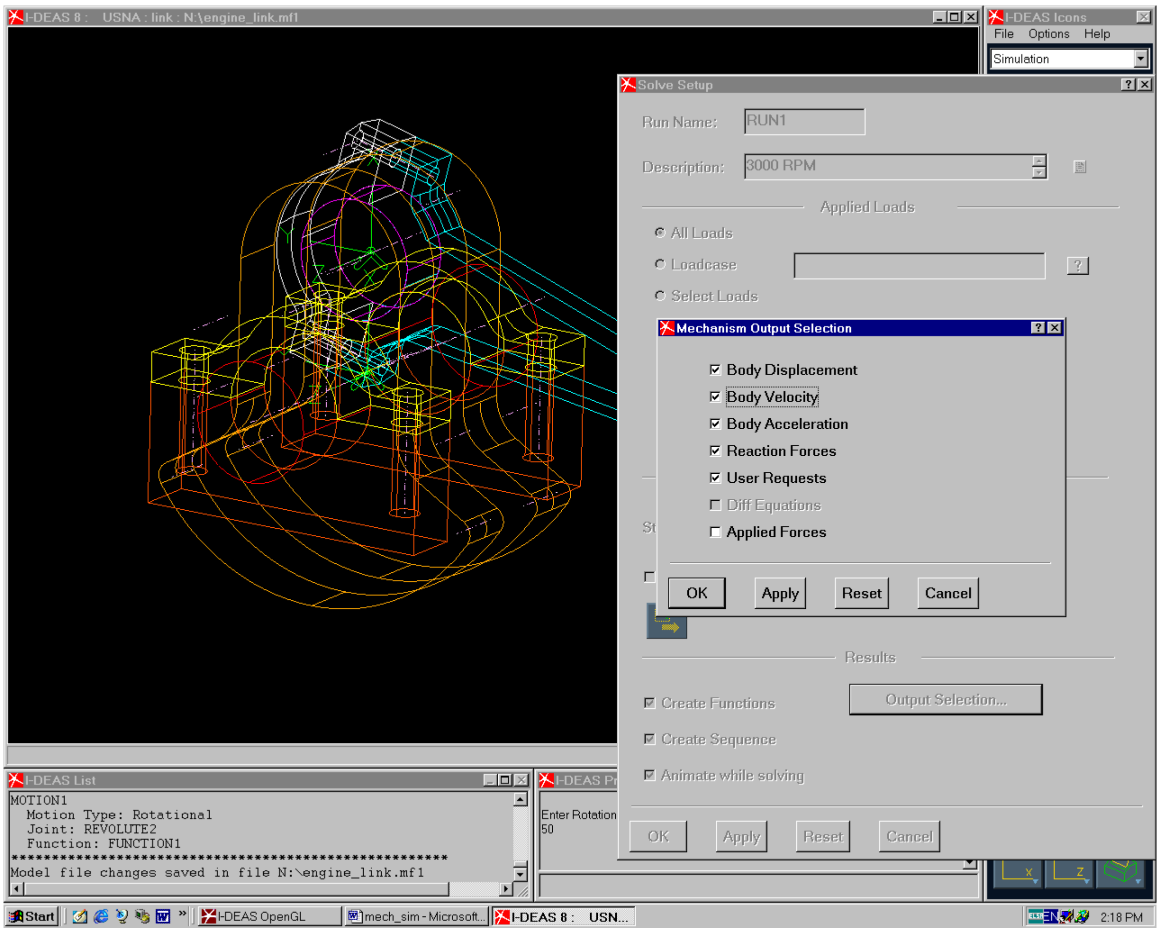
Save your file.

15. Pick the **Solve** icon and enter a description for this analysis. Set the **End Time** parameter to 0.02 seconds. Pick the **Output Selection** button.



16. Check the *Body Displacement, Body Velocity, Body Acceleration,* and *Reaction Forces*, boxes and then **OK,** then pick **OK** on the *Solve Setup* form.

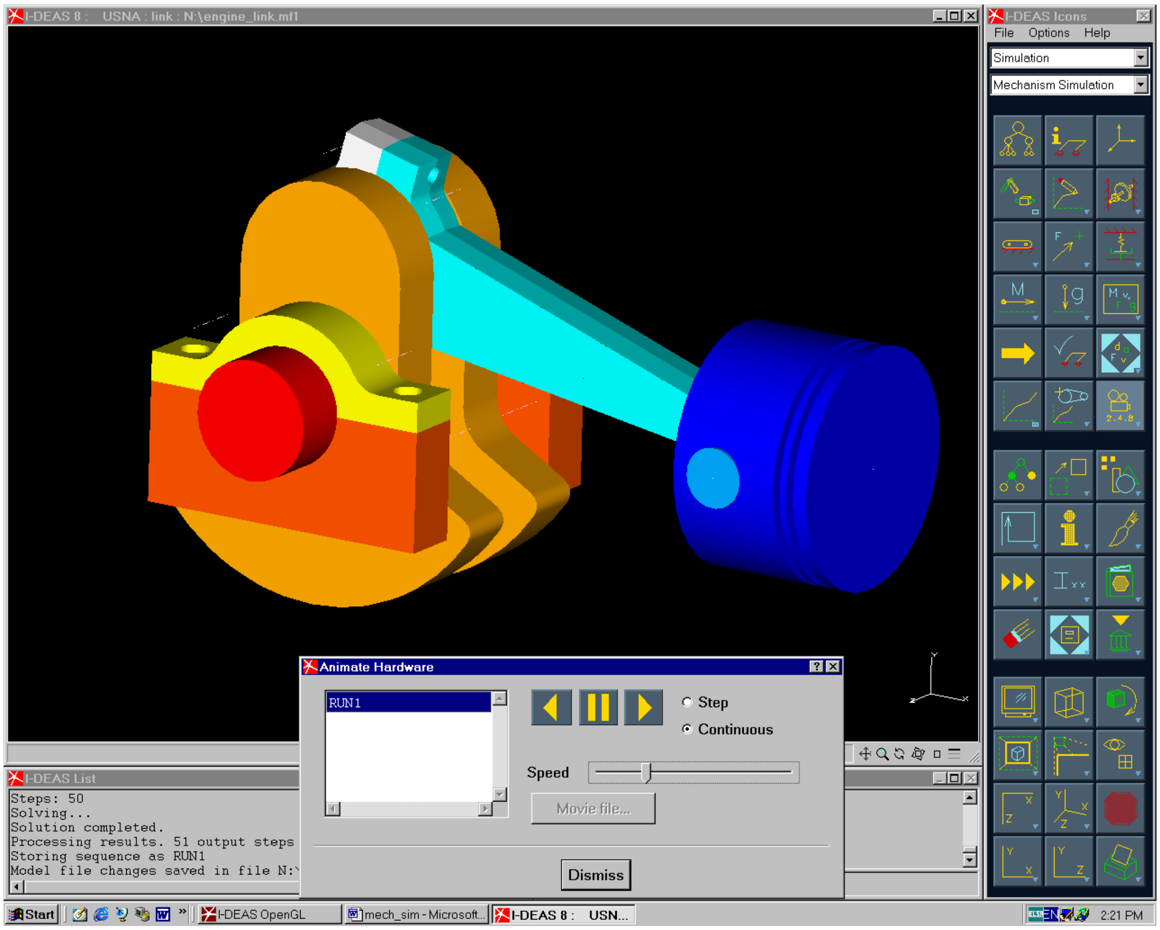
The list region should show some information about the solution progress. It should include a statement that the solution was completed.



Save your file.

17. Pick the **Animate Hardware**… icon, select *RUN1*, drag the pop-up to bottom of display area and hit the play button.

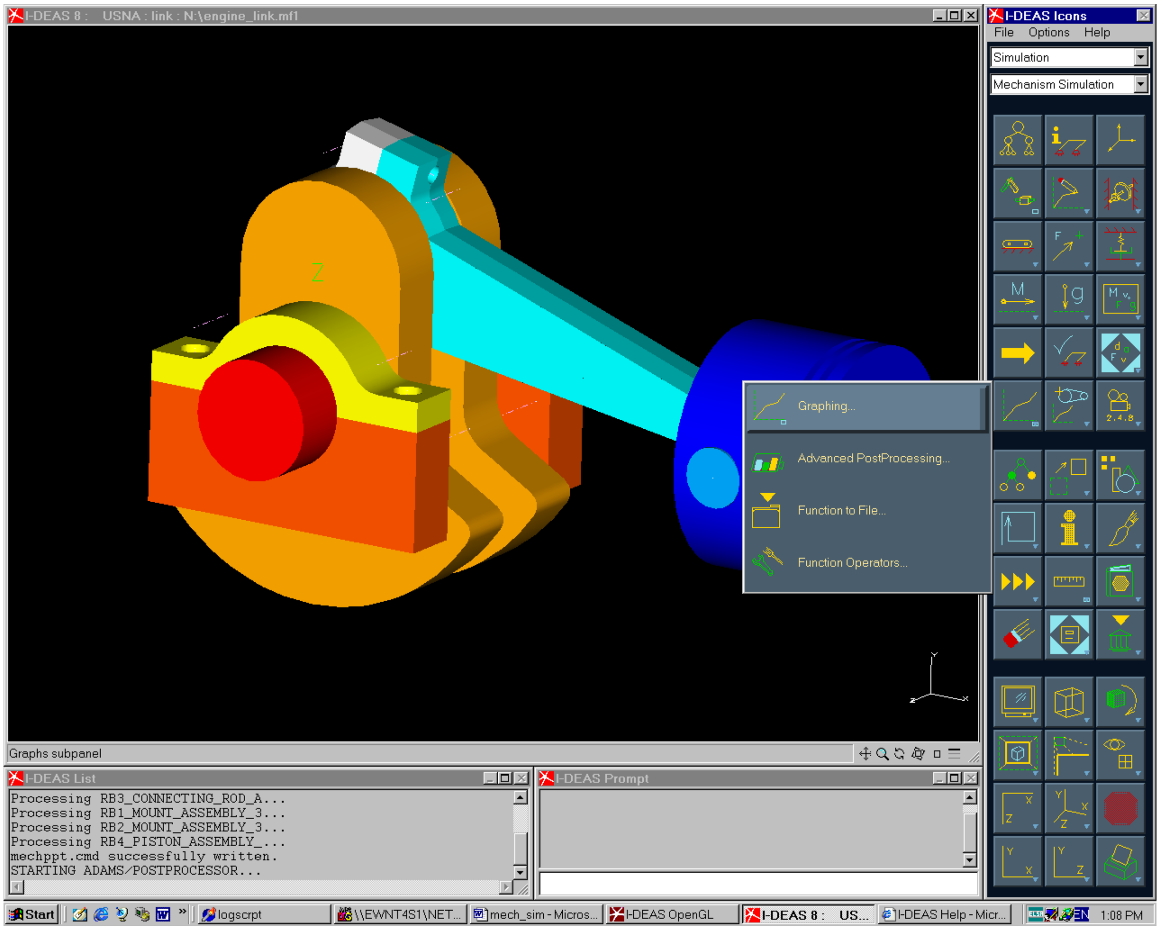
Hold on to your seat! Oooh! ahhh! Wow!



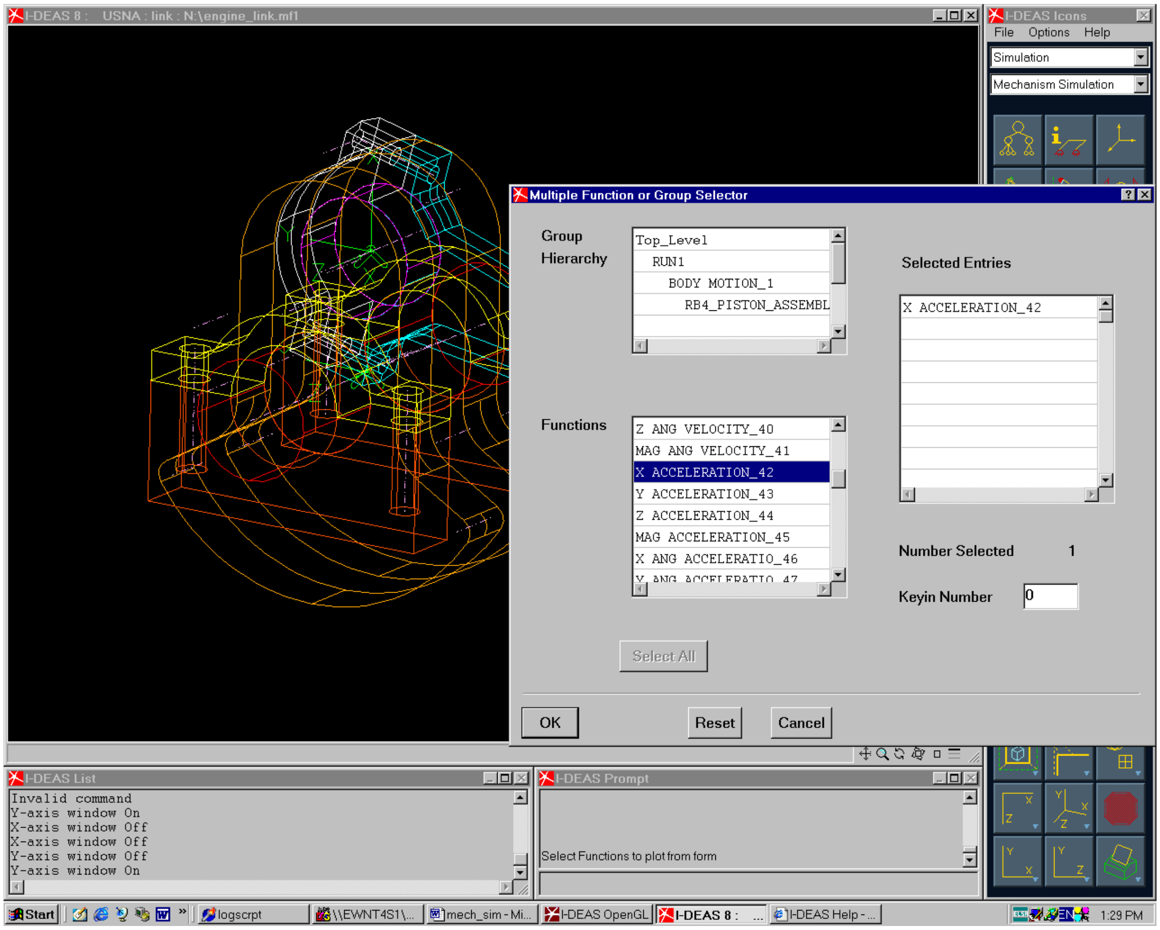
Save your file.

18. Now it is time to view the results of the kinematic analysis. As an example, we will look at the acceleration of the piston and the forces developed in the piston pin over the range of motion.

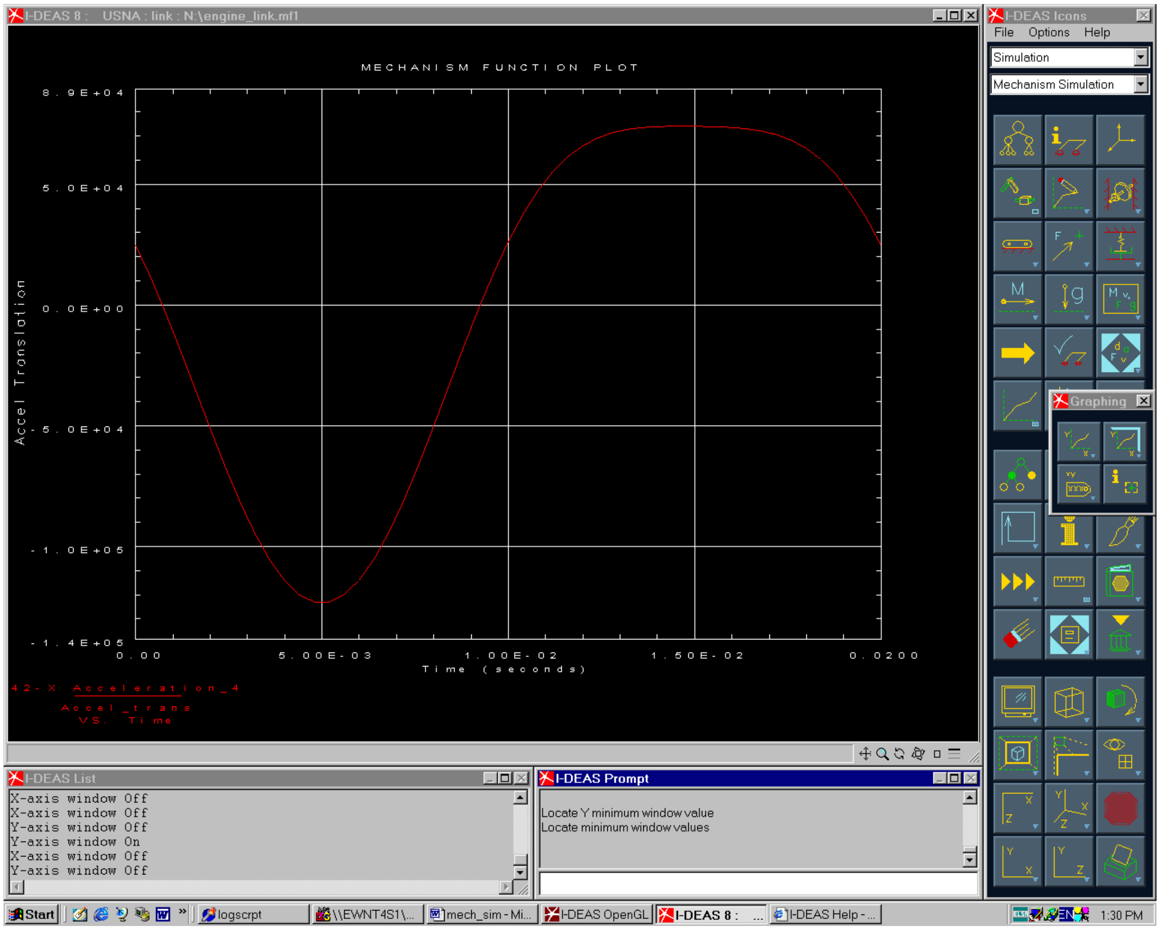
Pick the **Graphing** icon.



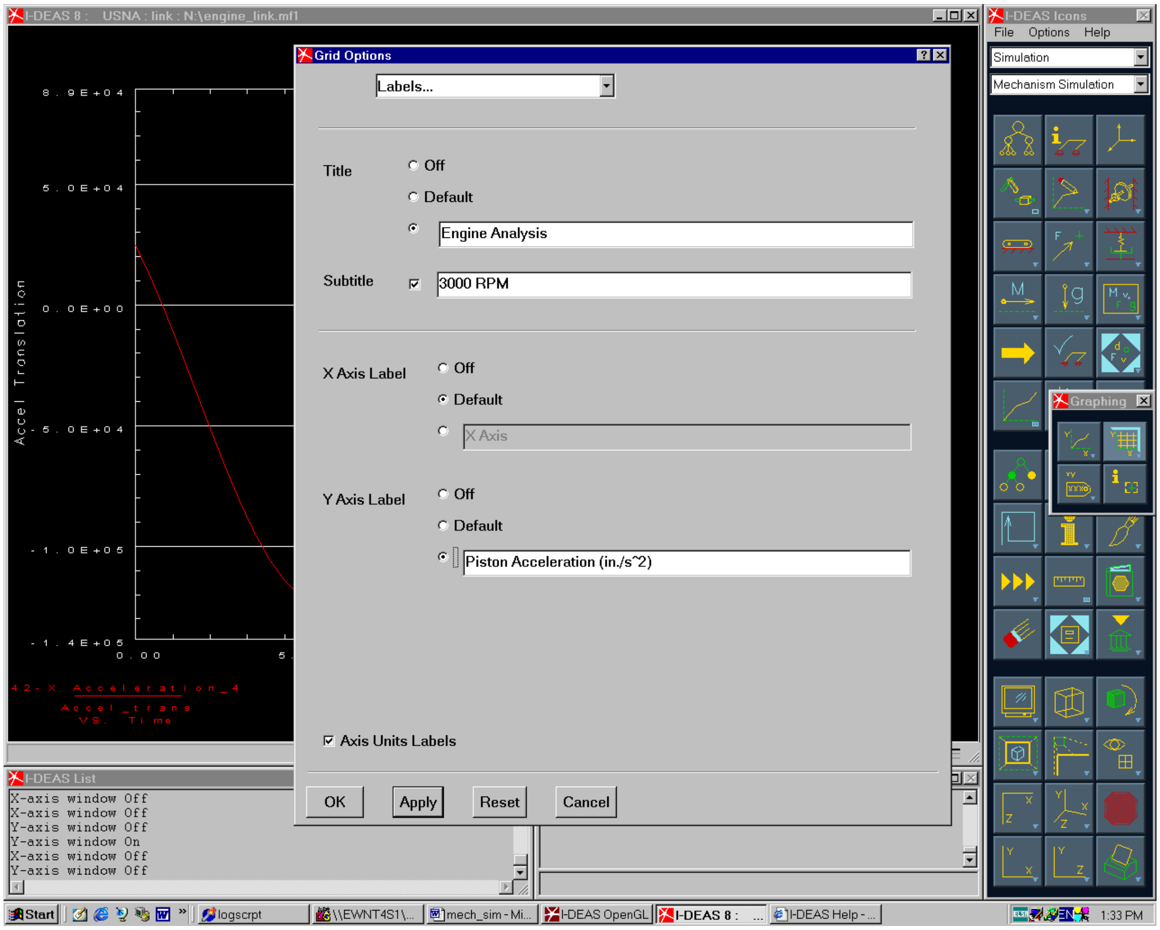
19. On the pop-up form, pick *RUN1, BODY MOTION_1, PISTON_ASSEMBLY, X ACCELERATION*, and then **OK**



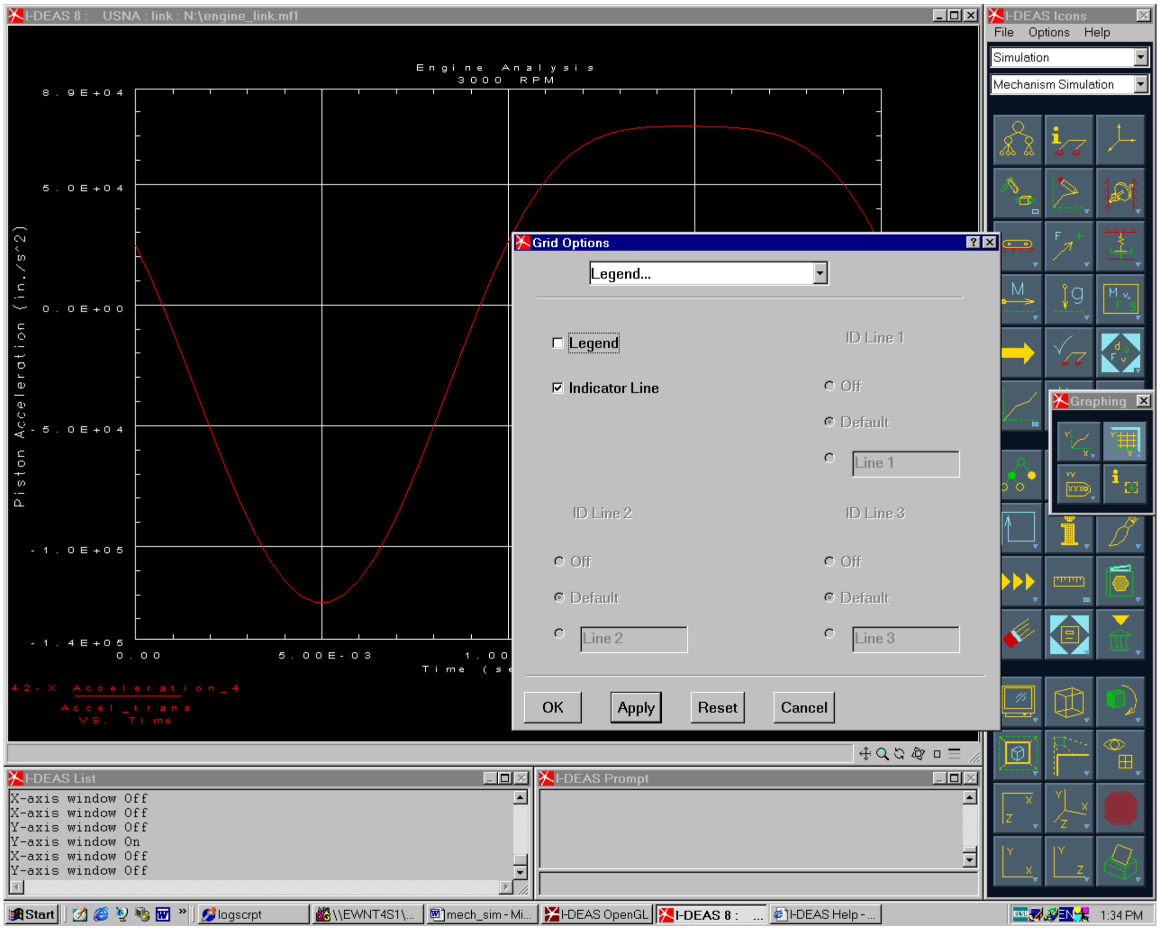
20. You should see a graph like that shown below. The next step is to customize the appearance of the graph to include titles, set the axis scales and format the traces.



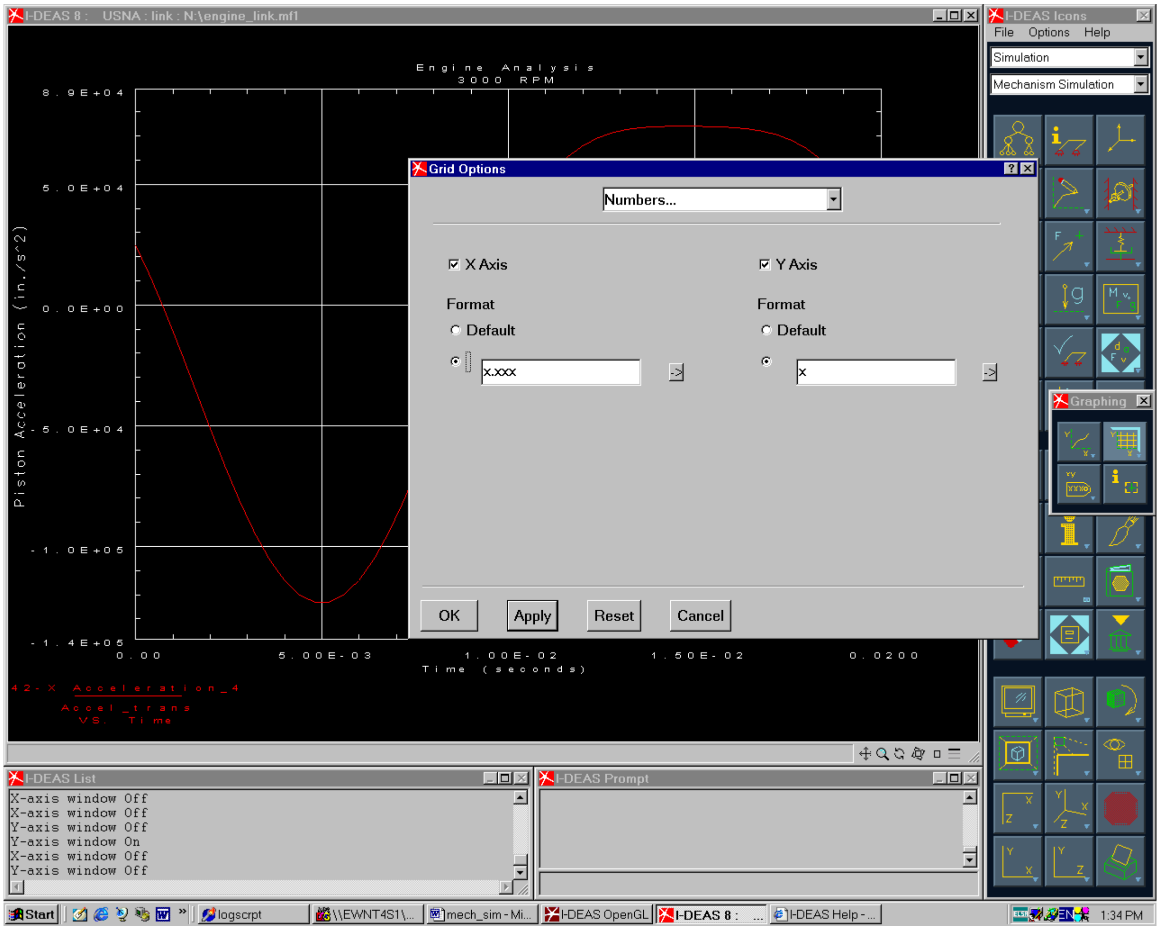
21. Pick the **Grid Options** icon. Pull down the **Labels…** menu and change the titles and labels to those shown below.



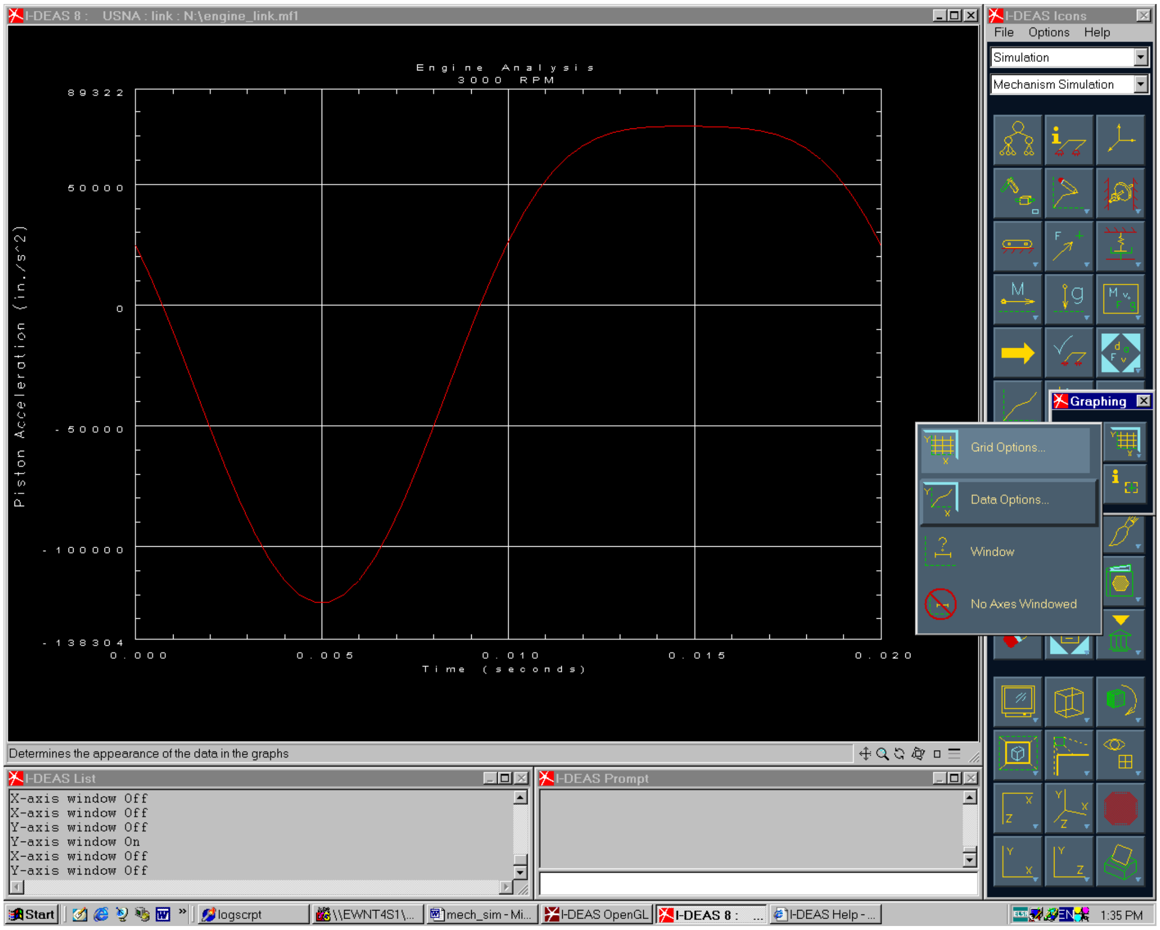
22. Pull down the **Legends…** menu and uncheck the legend box. (We only have one trace displayed so we don't really need one. Alternatively, we could leave it on and adjust the text displayed so that it was more meaningful.)



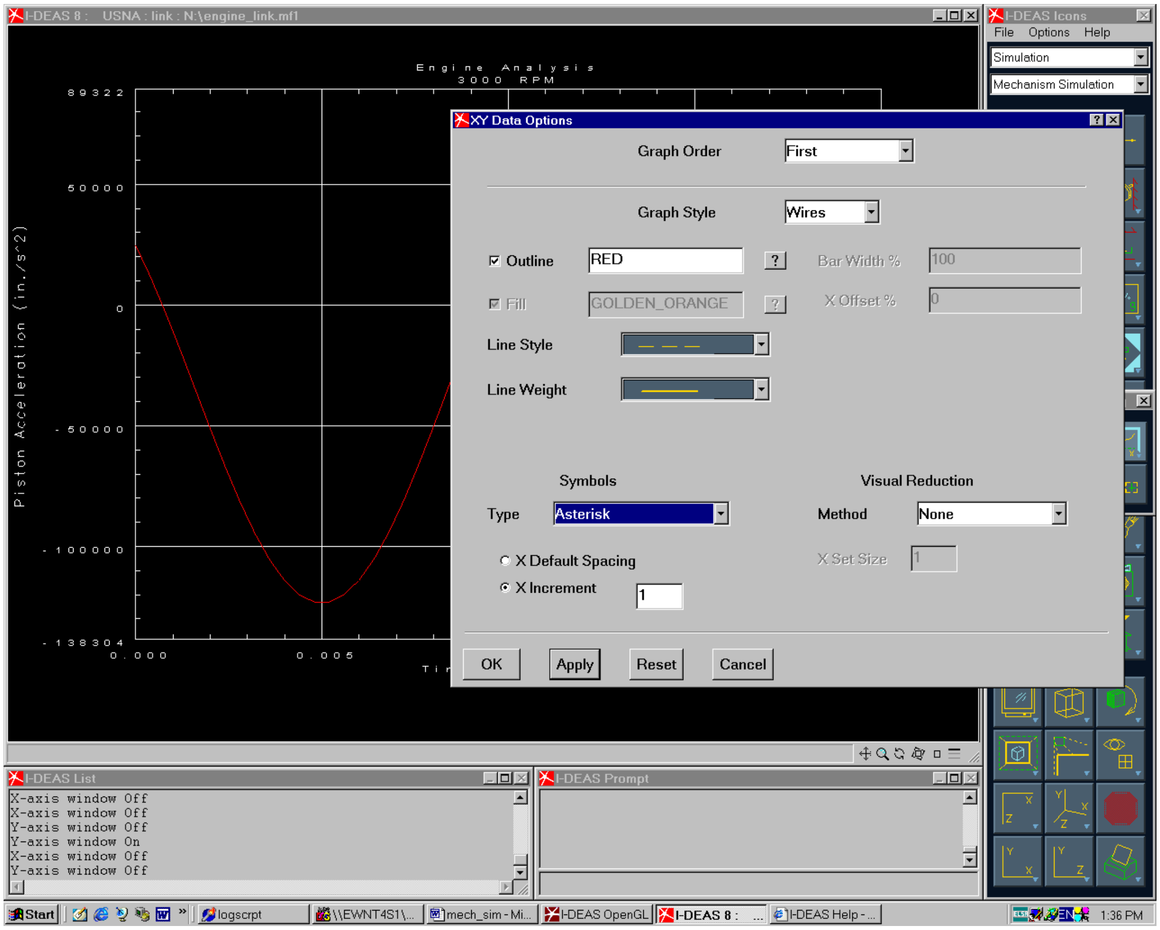
23. Pull down the **Numbers…** menu and adjust the x-axis format to be 3 decimal places and the y-axis to have no decimals.



24. Pick the **Data Options** icon to bring up menus that allow you to control the way the trace is displayed.

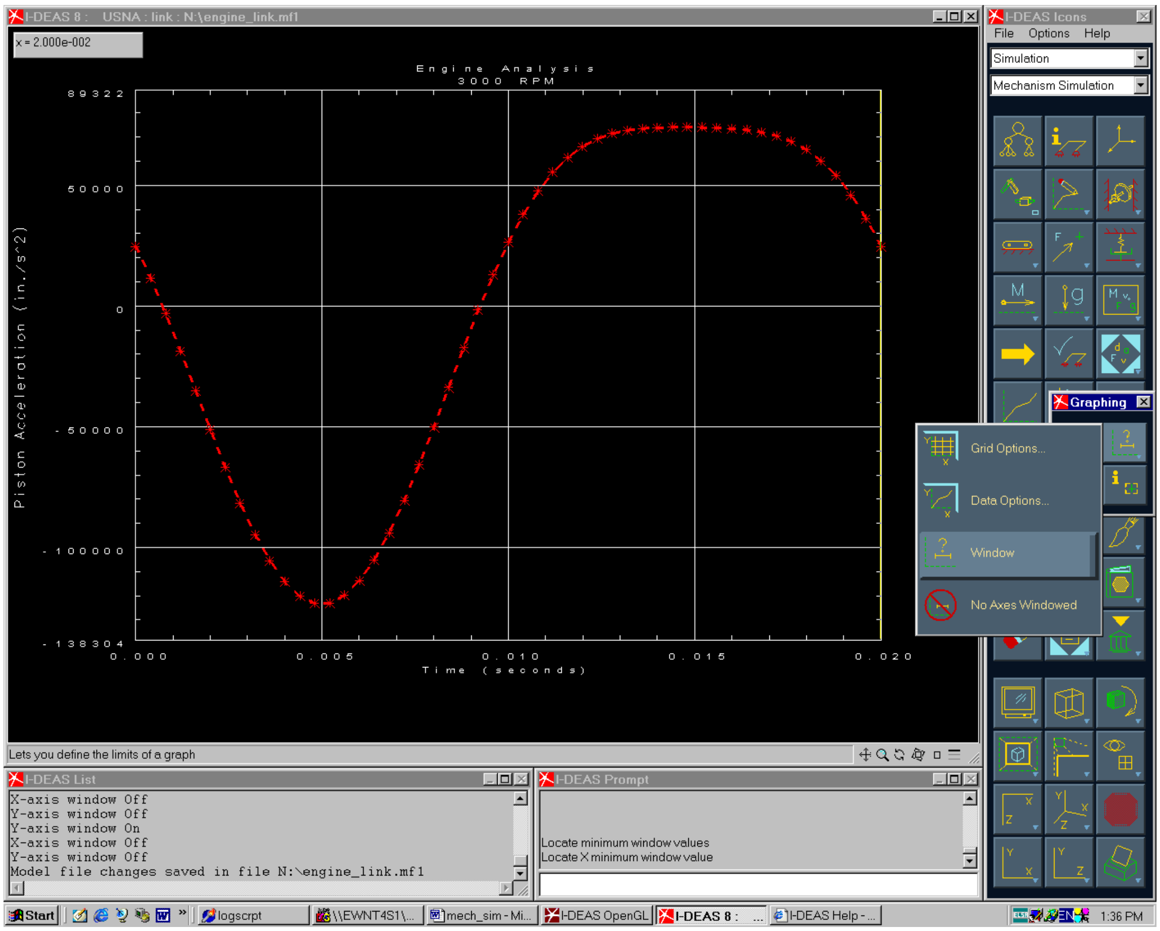


25. Change the *Line Style* and *Line Weight* for the trace. Select a symbol type for the plot and set the x-increment to 1, then hit **OK.**

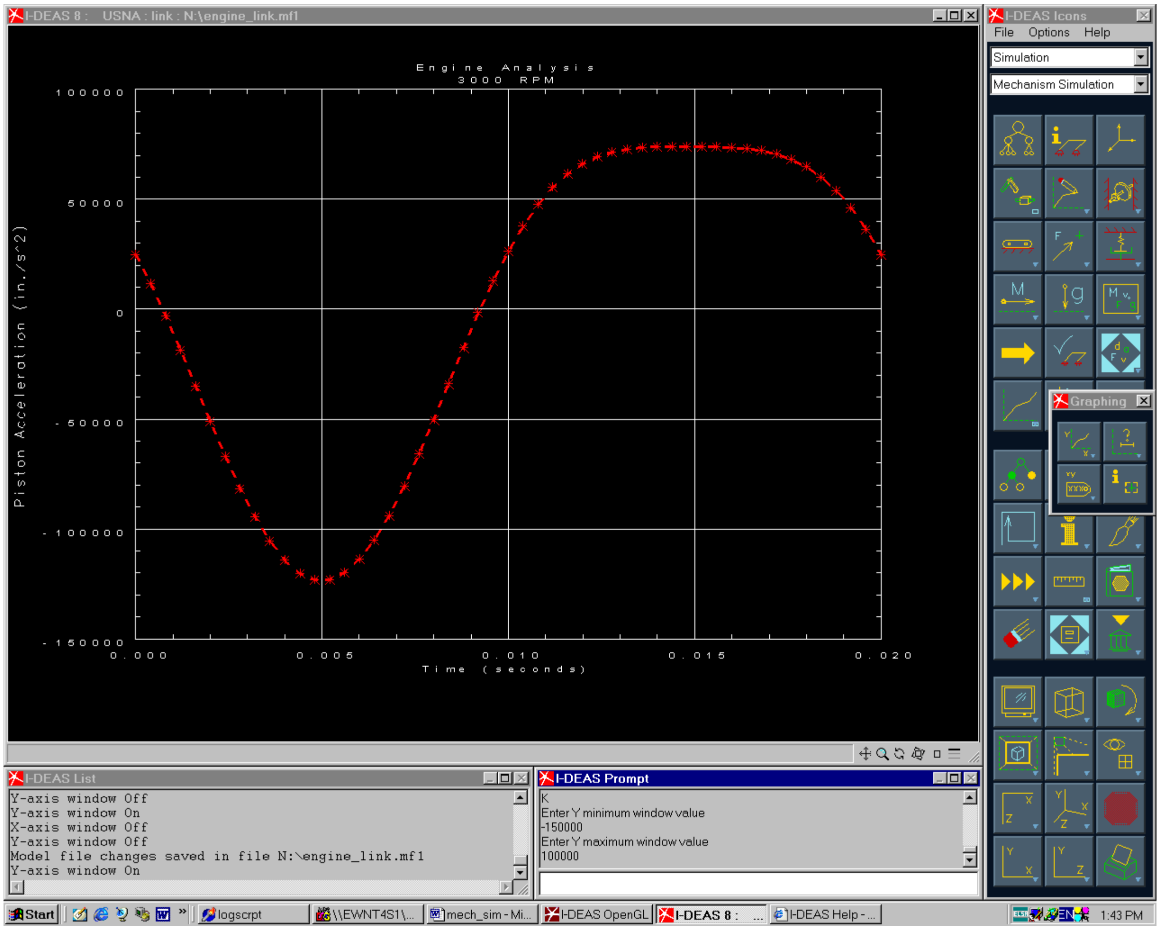


27. It would be nice if the range for the y-axis corresponded to some round number, so select the **Window** icon.

The prompt region will display, Locate minimum window values
RMB, Y Axis Only
Enter Y minimum window value
RMB, Key In
Type **–150000** into Prompt Region, Enter
Enter Y maximum window value
Type 100000 into Prompt region, Enter

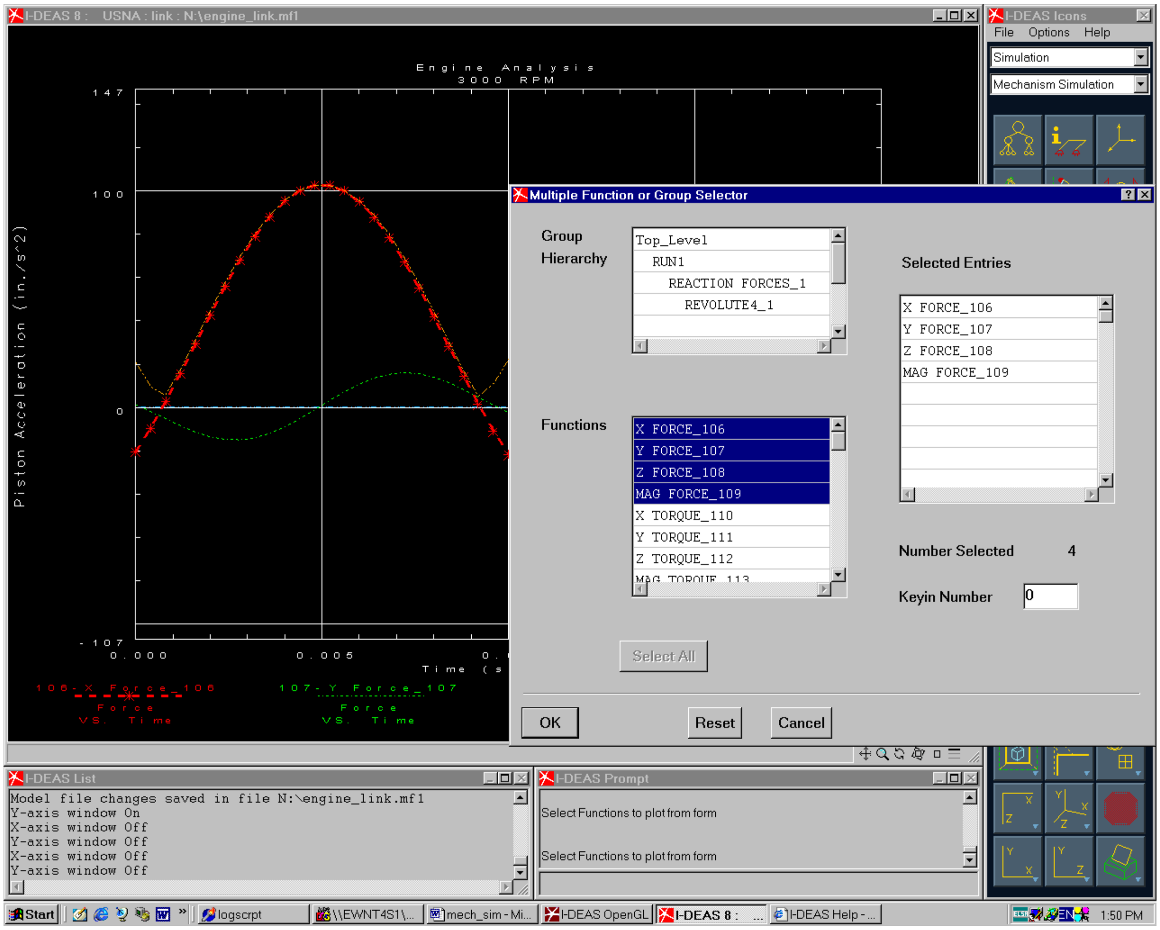


Your graph should look something like this…

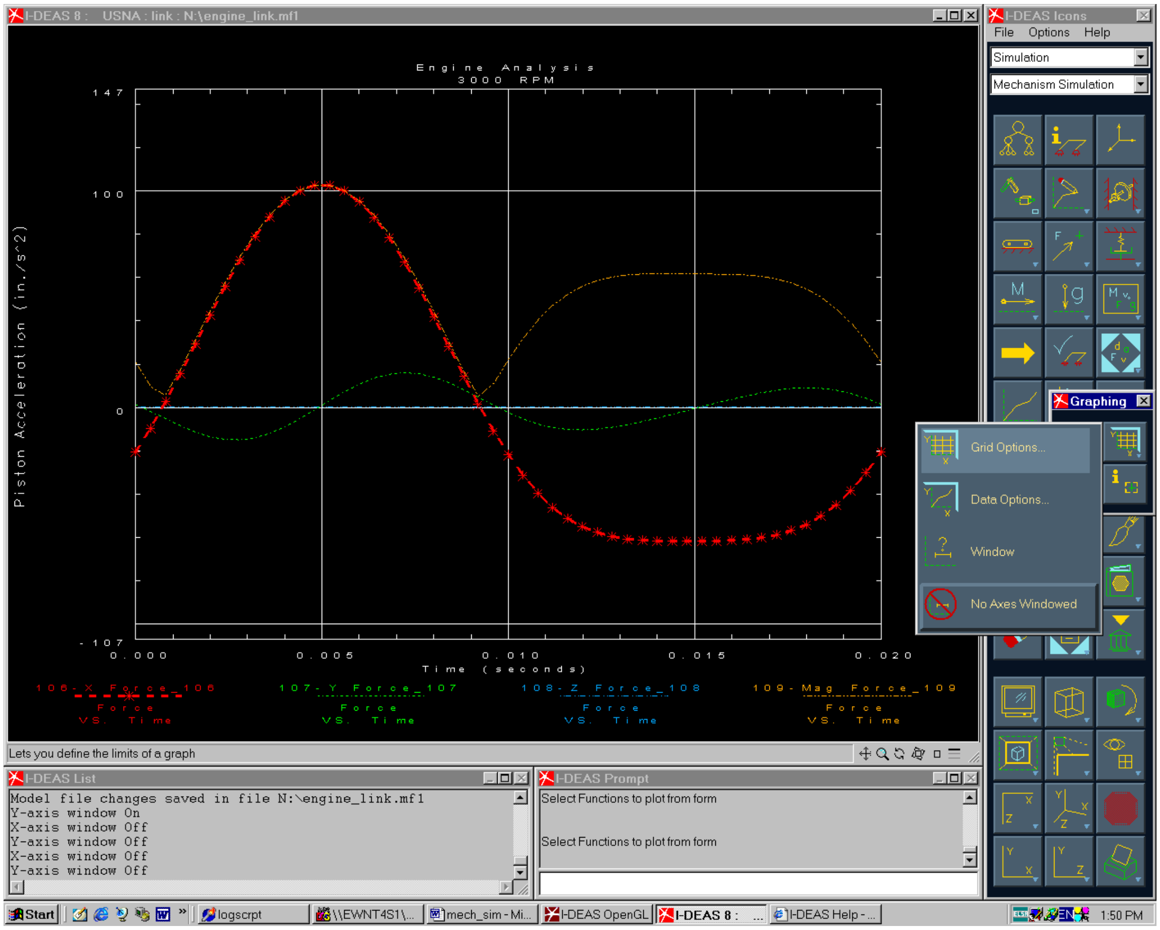


Generate a hardcopy of the graph by making a picture file and then printing the picture file.

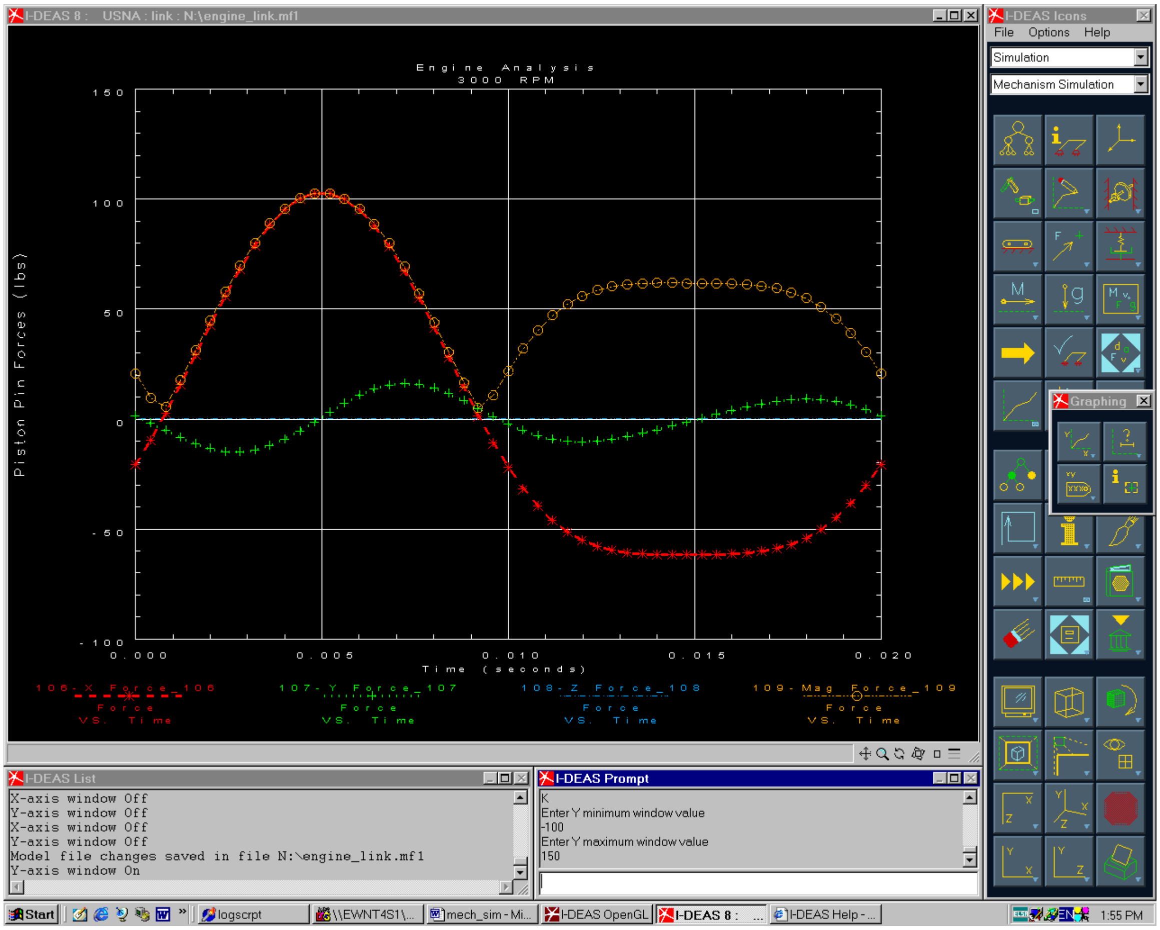
28. Next, take a look at the dynamic forces that develop during operation.
Pick the **Graph** icon, *RUN1, REACTION FORCES, REVOLUTE_4, Pick X, Y, Z* and *MAG FORCE*



29. Turn the y-axis windowing off so you can better see the results. Pick the **No Axes Windowed** icon.



30. On your own, adjust the labels, turn the legends back on and set the graph parameters to produce a nice graph like that shown below:



Generate a picture file if you want to print out the graph. The picture files are saved in the CGM format which is compatible with WordPerfect, Word and PowerPoint. You can easily import your picture files into reports or presentations that you prepare.

You can return to viewing your solid model by picking any of the display mode icons.

Save your model file.

Congratulations! You have just completed the last tutorial in the series. At this point you should have developed enough skill to proceed with your own mechanism design project. Don't forget about the online help manuals if you have questions.